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THIS VOLUME IS DEDICATED TO
PROF. DR. SÁNDOR KOCH
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GYULA GRASSELLY, SÁNDOR KOCH

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Acta Miner. Petr., Szeged

Szerkesztik

GRASSELLY GYULA, KOCH SÁNDOR

Kiadja

a József Attila Tudományegyetem Ásvány-Kőzettani Intézete
(Szeged, Táncsics Mihály u. 2.)

Kiadványunk címének rövidítése
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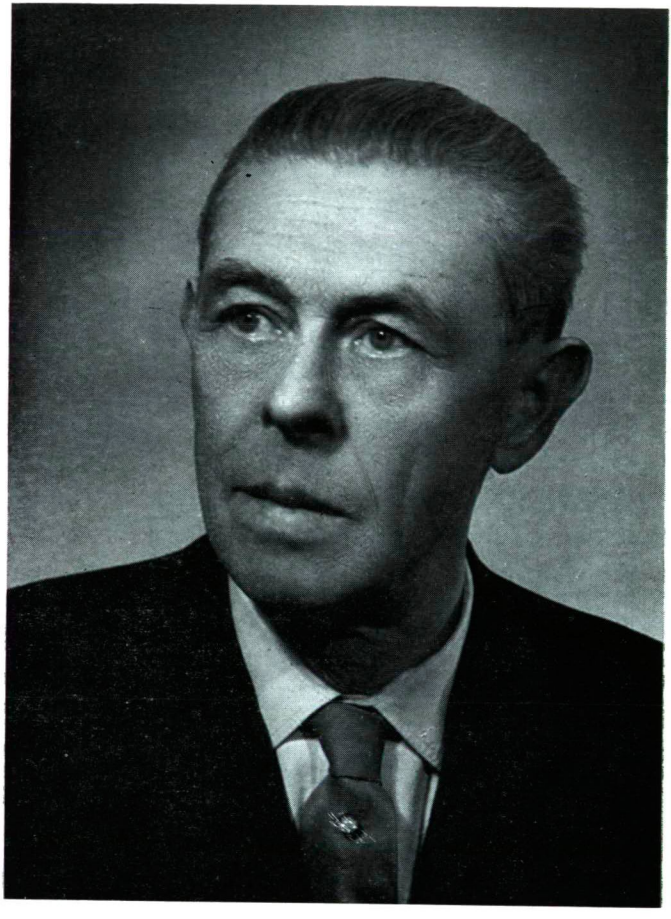

PROF. DR. SÁNDOR KOCH

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"The igneous rocks were attacked by the water and air and at the boundary of the lithosphere and atmosphere as well as of the hydrosphere and — due to the interaction of water, gases and rocks — the possibility arose for the biosphere, for the life promoting the higher development of the material."

This unforgettable sentence was uttered by Prof. SÁNDOR KOCH, the first lecturer of Geochemistry in Hungary, in one of his lectures in 1934.

It is the meaningful expression of the advantageous contradictions of the world in development, of the correlation between the movements degraded as lifeless and the living, organized material. In the static view of the then mineralogy it was a new, pioneering, modern, forward-pointing attitude.

He has declared and still declares the marvellous correlations and enthusiastic beauty of Nature since 35 years from his chair, and what is more important, far from the official educational forum, at the numerous and unforgettable meetings — in the blooming meadows, in the mines before glittering crystals, in the bright light of the beauty of artistic and natural works — in the circle of his kind close family as well as in that of his disciples — as we used to express — in the circle of the great "Koch-family".

We, his disciples, speak of and with him only in the tone of the limitless affection and gratitude. He is one of the many, whose faults are unknown to us, and if he has any, it is to be attributed to exaggeration of his human attitude.

To enumerate the periods of a scientific career, is a simple and customary task appreciating any scientist. Concerning SÁNDOR KOCH, the man and the educator, however, such a thing is to be said that can not be applied but to very few other scientists.

He was born in the memorable year of the Hungarian history (1896), in the millenary anniversary of the country and grivious sequence of the great dramas of the Hungarian history took place during his life. In the tempests of the history he firmly stood on the high rock of the humanism. In every sorrowful period of the collective judgement of the individuals, he sided whole-heartedly and with his activity with gifted individuals, opponing the viewpoints of the human and Hungarian community and of the sciences against the trends of malice.

With the compass of the well recognized interests of the Hungarian community the international sciences, and that of the high-grade humanism he firmly steered, the ship of the University of Szeged many a times in angry seas.

The great pedagogist has already been awarded with the highest Hungarian distinctions, among them with the Kossuth-price by the Socialism-building country.

Some of the most important steps of his scientifical activities: the first genetical description of the minerals of the localities of the Carpathian-basin, the compilation

of geochemistry of the usable elements has already been published in early thirties. His book on the gems, the mineralogy as well as the comprehensive monography of Hungary's minerals recently published, all are essentially reflections of — on paper hardly to be enlivened — a permanent, high-levelled scientifical enthusiasm.

He must be seen with some crystal-miracle collected long ago, with a gorgeous mineral-group in his hands, he must be heard explaining his students the smallest details and the marvellous whole of Nature rendering it alive, beautiful and exciting, and only then one can learn his really conspicuous personality.

Using his own statement, his aime is to educate not only "mineralog" but "minerophil" generations and for this very reason his teaching and education are far extended over the circle of experts strictly taken and beyond the boundaries of our country.

His disciples have been and are working even to day within the broad field of the geological sciences but apart from the real field of the mineralogy. Among them may be found public school teacher, geochemist, magmatic petrographist and, as the writer of these lines, also oil geologist.

Independent of the professional field, however, Prof. Dr. SÁNDOR KOCH's education about the immeasurable affection of Nature and of its most important member, the human beings, about flowers, mineral-forming processes, beautiful crystals, about the works and production of great men, painters, poets and musicians, about the high appreciation and pleasure of life are still freshly living in our mind.

These are that keep the 70-year old SÁNDOR KOCH together with all his grateful and true disciples young for ever.

Budapest, 24 June 1966.

DR. GYÖRGY KERTAI
President of the Central Geological Office,
tit. professor of university,
corr. member of the Hungarian Academy of Sciences

„A tűzi eredésű kőzeteket a víz és levegő támadta meg és így a lithoszféra, atmoszféra és hidroszféra határán, a víz, a gázok és a kőzetek egymásra hatásából létrejött a lehetőség az anyag magasabb fejlődését elősegítő élet, a bioszféra számára."

Ez a felejthetetlen mondat szerepelt a Geokémia első magyarországi előadójának, Koch Sándornak egyik 1934-ben tartott előadásán.

A fejlődésben levő világ hasznos ellentéteinek nagyszerű kifejezése ez. Az élettelennek degradált anyag mozgásaiban levő összefüggés az élő, szervezett anyaggal. Az akkori mineralógia még statikus szemléletének idején új, úttörő, modern, előremutató tanítás.

A természet nagyszerű összefüggéseit és lelkesítő szépségét hirdette és hirdeti 35 éve az egyetemi katedrán és ami még fontosabb, távol a hivatalos előadás fórumától azon a sok és felejthetetlen találkozáson, — virágos réteken, bányákban csillogó kristályok előtt, a művészeti és természeti alkotások szépségének sugárzásában, — kedves szűk családja, és ahogy mi elneveztük, tanítványainak, a nagy „Koch családnak" körében.

Mi tanítványai csak a túláradó szeretet és hála hangján beszélünk Vele és Róla. Egyetlen ember a sok közül, akinek jóformán hibáját nem ismerjük, ha van hibája, úgy az csak jótulajdonságainak túlzásaiból ered.

A tudományos pálya állomásait felsorolni minden tudós méltatásánál egyszerű, megszokott feladat. Koch Sándorról az emberről, a nevelőről elsősorban azonban olyasmit kell elmondani, amit kevés más tudósról lehet.

A magyar történelem nagy évében a Milleneum idején született (1896) és életében a magyar történelem nagy drámáinak fájdalmas sorozata játszódott. A történelem okozta viharokban mindig a humanizmus magas szikláján állott. Az egyéniségek kollektív megítélésének minden szomorú időszakában Ő teljes szívével és tevékenységével az értékes egyéniségek mellé állt, az emberi és magyar közösség, a tudomány szempontjait helyezte szembe a rosszindulat áramlataival.

A szegedi egyetem hajóját sokszor viharos vizeken, a magasfokú humanizmus, a nemzetközi tudomány és a magyar közösség jól felismert érdekeinek iránytűjével biztos kézzel vezette.

A szocializmust építő ország jutalmazta már a nagy pedagógust a legmagasabb magyar kitüntetéssel, a Kossuth-díjjal.

Tudományos tevékenységének nagy jelentőségű állomásaiként: a Kárpát-medence bányahelyei ásványainak első genetikus leírása, a hasznosítható elemek geokémiájának összefoglalása már a 30-as évek elején megjelent. A drágakövekről írott könyve, az ásványtan, a magyar ásványtan története és a legutóbb megjelent Magyarország ásványainak összefoglaló monográfiája, mind tulajdonképpen egy állandó, magas szintű tudományos elragadtatás, papíron nem eléggé megelevenít-hető tükörképei. Látni kell Őt valamelyik régen gyűjtött kristálycsodával, vagy színpompás ásványcsoporttal kezében. Hallani kell, amint tanítványainak magyarázza élővé, széppé, izgalmassá teszi a természet legkisebb részletét és csodálatos egészét, és csak akkor ismerjük meg igazán kimagasló egyéniségét.

Az Ő szavával élve, „nem mineralóg:" hanem „minerophil" emberek nevelése a célja és ezért terjed tanítása messze túl a szűken vett szakemberek körén és az ország határán.

Tanítványai ma a földtudomány széles területén, a szoros értelemben vett mineralógiától elszakadva dolgoznak. Van közöttük középiskolai tanár, geokémikus, magmatikus petrográfus és mint e sorok írója, olajgeológus is. A szakmai területtől függetlenül mindannyiunkban elevenen él Dr. Koch Sándor tanítása: a természet és annak legfontosabb része, az ember végtelen szeretetéről, virágokról, ásványképző folyamatokról, színpompás kristályokról, nagy emberek, festők, költők és zenészek alkotásairól, az élet magasszintű értékeléséről és élvezetéről.

A 70 éves Koch Sándort ez teszi valamennyi hálás és igazi tanítványával együtt örökké fiatallá.

Dr. Kertai György
a Központi Földtani Hivatal elnöke,
c. egyetemi tanár,
MTA levelező tagja

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MINERALOGY OF THE WEATHERING PROFILE OF A VOLCANIC BRECCIA IN THE ČESKÉ STŘEDOHOŘI Mts.

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INTRODUCTION

The investigation of Tertiary volcanic rocks of the České středohoří Mts. (in northern Bohemia) carried out between 1958—1966 was directed particularly to the study of volcanic diatremes and their fillings. The geology and mineralogy of this area was already studied in detail by J. E. HIBSCH [1926, 1934].

GEOLOGICAL SETTING AND GENETIC CONDITIONS

The young volcanics of the České středohoří Mts. are of an alkaline character and date from the Miocene to Pliocene. The bulk of volcanics belong to the first (Miocene) volcanic phase; the second, Pliocene phase was less intensive. In the intervening period of volcanic rest, the rocks were exposed to strong climatic weathering. Basic rocks were affected by montmorillonitization and the acid ones by kaolinization.

The secondary minerals studied are confined to the weathering profile of the breccia-like filling of the diatreme at the Sviňky locality near Hořenec (near Bílina spa, in the southwestern part of the České středohoří Mts.).

The diatreme is of a considerable areal extent, of about 1,000 × 320 metres *(Fig. 1)*, and is filled by earlier vent (volcanic) breccia and the younger massive igneous rock, that corresponds petrographically to vitreous picritic leucite basanite and occurs in a dyke form inside the diatreme.

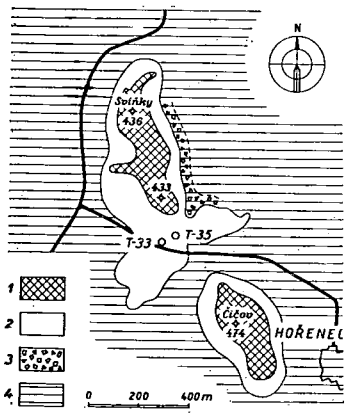

Fig. 1. Geological map of the Sviňky diatreme in the SW of the České středohoří Mts., with the location of boreholes: *1* — Massive vitreous picritic leucite basanite; *2* — vent (volcanic) breccia; *3* — crush zone of Cretaceous sediments; *4* — marlstones (Coniacian).

The vent breccia itself is composed of the fragments of picritic basaltic rock (90 per cent) altered to montmorillonite, and the fragments (xenoliths) of rocks (10 per cent) derived either from the crystalline basement (granulite, pyrope-bearing pyroxene peridotite) or from the Upper Cretaceous sedimentary complex (marlstone, fine-grained sandstone).

In the southern part of the outcrop of vent breccia (in the vicinity of T-33 and T-35 borings), solid, up to 20 cm large chert concretionary forms and xenoliths of Cretaceous sediments of about the same size weather out from the eluvium. Material for the detailed study of the clay mineral forming the substantial part of the vent breccia was taken from the borehole T-35, where the weathering profile reached to a depth of 20.70 m. In the borehole the following succession was established: clayey arable soil with basalt fragments and sporadic weathered-out concretions and xenoliths (0.20 m), brownish-yellow eluvial clay with accumulated concretions and xenoliths at the base (0.90 m); the vent breccia altered to clayey material, yellow-green in colour (to a depth of 2.50 m), yellow (to 4.20 m) and brownish-green (to 8.40 m). The brown colouration is produced evidently by goethite which at this depth was determined by X-ray analysis. The goethite pigment does not appear at lower horizons. The clay mineral proper constituting the substantial part of the rock has been determined by X-ray method as montmorillonite. Below the level of climatic weathering (deeper than 20.70 m), the breccia is greyish-blue, solid, containing carbonates — calcite and siderite — in addition to montmorillonite.

It has been ascertained that within the zone of recent weathering the primary siderite (preserved at a greater depth) is transformed into goethite, the most stable form of ferrous compounds under these conditions. The alteration of different Fe-minerals under weathering conditions is a well-known and widespread phenomenon [J. D. DANA—E. S. DANA 1951].

In the borehole T-33, from which the two chert concretions that will be described below, were taken (at a depth of 21.20 m), fossil weathering reaches 24 m under the surface. The brownish colouration by goethite is observable to a depth of 14.40 m and re-appears between 16—18.70 m.

The X-ray identification of minerals in the rocks studied was performed by GUINIER method, after P. M. WOLFF, in the Laboratory of the Geological Survey of Czechoslovakia, Prague. The radiation used-Cu, exposition 24 hours at 40 kV and 25 mA.

DESCRIPTION OF THE MINERALS STUDIED

From the point of view of genesis, the examined forms should be divided into chert concretions and xenoliths of Cretaceous, in part silicified sediments. In addition to various forms of SiO_2, some secondary minerals have been identified.

(A) Secondary minerals of xenoliths

The xenoliths of Cretaceous sediments studied were of two types: *(1)* Weakly silicified marlstone and *(2)* decalcified fine-grained spongolitic sandstone with muscovite and glauconite.

(1) The xenolith of weakly silicified marlstone, 8 cm in size, is slightly tinted by ferrous pigment to a distance of 1 cm under the surface. Inside the xenolith there is a lenticular cavity (2—3 cm across) lined with a continuous coating of

finely crystallized aragonite *(Pl. I/1)*. In places, spherolitic aggregates of younger clear aragonite developed, accruing round the crystallization centers to a continuous lining, filling the whole breadth of the fissure *(Pl. I/2)*.

(2) Whitish decalcified spongolitic fine-grained sandstone with muscovite and glauconite. The fissures extending from the surface into the interior of the xenolith are lined by rusty-brown fine coatings of goethite. The wider fissures (up to 2 mm) are covered by lenticular crystals in the form of low rhombohedra (—1/2R), oriented differently to the substrate *(Pl. II/1)*. The small crystals are dark-brown, opaque, with glassy lustre. Their maximum size is 1.2 mm. The general morphology of idiomorphic crystals and the characteristic rounding of rhombohedral faces indicate that they are typical forms of siderite *(Pl. II/2)*. X-ray and optical analyses, however, have identified the mineral as goethite. From this it follows that in the weathering zone goethite pseudomorphs after siderite developed.

(B) Chert concretions and their minerals

On the basis of morphology, three types of concretions may be distinguished: *1)* concretions with concentrically layered texture *(Pl. III/1)*, *2)* with massive filling and *3)* with a hollow interior *(Pl. III/2)*.

The outer zone of all concretions is transected by a network of radial cracks which open outwards, forming the characteristically grooved surface *(Pl. IV/1, IV/2)*.

1. In the chert concretions with concentrically layered structure *(Pl. III./1)*, laminae (about 1—3 mm wide) of yellow to brown compact chert alternate with softer laminae of pale yellowish colour. The compact chert laminae are cut by radial cracks *(Pl. V/ 1)*. In light-coloured soft laminae very fine-grained quartz was identified by X-ray method.

2. A chert concretion of yellow-grey colour with very typically developed radial cracks reaching to about 1.5 cm under the surface is shown in *Pl. IV/2*. At the outer margin of an open fissure, there is a group of 4 mm long clear gypsum crystals with a strongly corroded surface *(Pl. V/2)*.

Other chert concretions with dense interior are light green-grey or brown and of a typically conchoidal fracture. Radial hair-like cracks filled by earlier chalcedony and younger hyalite reach from the surface to about one third of the diameter. The concretion shown in *Pl. VI/1* has a greenish-grey unsilicified core of claystone character which may represent the centre of the nodule formation. On the outer side of the concretion, sporadical wider cracks are lined by warty coating of hyalite which passes inwards into chalcedony. In places, hyalite forms about 0.5 mm large globules *(Pl. VI/2)*.

3. Chert concretions with central cavities are yellowish to brownish-grey with a typically conchoidal fracture of the chert mass. Cavities of irregular shape *(Pl. III/2)* originated similarly as surface cracks by the drying of originally colloidal SiO_2 mass. Mn- and Fe-oxides form locally dentritic coatings on radial cracks. The cavities have again a lining of chalcedony that pass into colourless hyalite towards the surface. The total thickness of the lining is about 1 mm *(Pl. VII/1)*. The hyalite lining has a typical vitreous lustre and the index of refraction equal to 1.4485. The texture of chalcedony with hyalite lining is well visible on the photomicrograph of the transversely broken stalactite-like form *(Pl. VII/2)*. Between partly crossed nicols, the boundary between radiate chalcedony and amorphous hyalite is discernible. The filling of outer cracks in this type of concretions is ana-

logous to that of massive concretions. Additionally, earlier calcite has been observed in this sections under the microscope.

Unlike the above described concretion, the nodule shown on *Pl. III/2* has the interior covered by finely crystalline colourless quartz which is lined by a thin coating of younger chalcedony.

The individual minerals of chert concretions were identified by optical and DEBYE—SCHERRER X-ray methods.

CONCLUSION

Within the range of fossil and recent climatic weathering of a vent breccia, a regular depth-distribution of newly formed minerals has been ascertained, both in the volcanogenic material itself and in the xenoliths of Cretaceous sediments. Beyond the reach of recent weathering, siderite is generated in the breccia and in xenoliths, altering into goethite in the superficial zone of recent weathering.

In some cases chert concretions originate around the xenoliths of Cretaceous sediments. Silicon dioxide seems to have been liberated during the conversion of the volcanogenic component of breccia into montmorillonite.

The origin of carbonates is confined to the fissures in the xenoliths of Cretaceous sediments. In chert concretions the carbonates occur quite scarcely. All forms of SiO_2 are altogether absent from the xenoliths.

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EXPLANATION OF THE PLATES

Pl.I. fig. 1. A halfed xenolith of weakly silicified marlstone with a lens-shaped cavity. Natural size 8 cm.
fig. 2. Spherolitic aggregates of aragonite in a lens-shaped fissure. Magn. 1:2.

Pl. II. fig. 1. Xenolith of spongolitic fine-grained sandstone with rhombohedral crystals of goethite pseudomorphs after siderite 1:1.
fig. 2. Rhombohedral crystals of goethite pseudomorphs after siderite. Magn. 1:10.

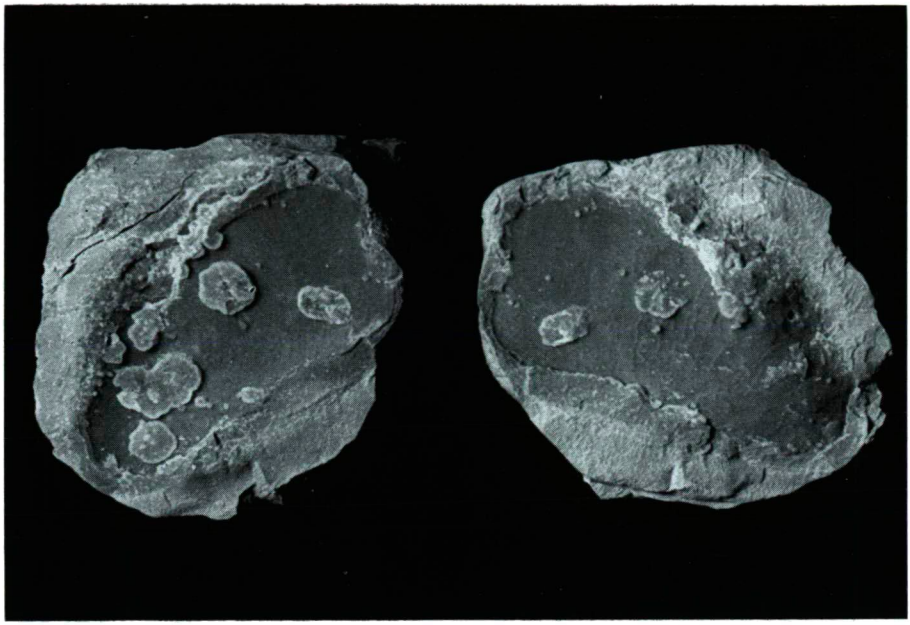
Pl. III. fig. 1. Chert Concretion with a concentrically layered texture. Natural size 11 cm.
fig. 2. Chert concretion with internal cavities lined with finely crystalline quartz. 1:1.

Pl. IV. fig. 1. Chert concretion with a typically grooved surface. Natural size 17 cm.
fig. 2. Chert concretion with a dense network of radial cracks. 1:1.

Pl. V. fig. 1. The alternation of compact chert layers with layers of softer fine-grained quartz. Radial craks are wellseen in chert layers. Magn., 1:20. (A detail from *Pl. III/1*)
fig. 2. A group of gypsum crystals in a fissure of the chert concretion shown in *Pl. IV/2.* Magn. 1:10.

Pl. VI. fig. 1. Chert concretion with unsilicified clay core. Natural size 10 cm.
fig. 2. A coating of hyalite globules on the fissure of the chert concretion shown in *Pl. VI/1.* Magn. 1:10.

Pl. VII, fig. 1. Cavity in a chert concretion with chalcedony and hyalite linings. Magn. 1:2,5.
fig. 2. A small chalcedony stalactite passing into amorphous hyalite. Partly crossed nicols. Magn. 1:50.



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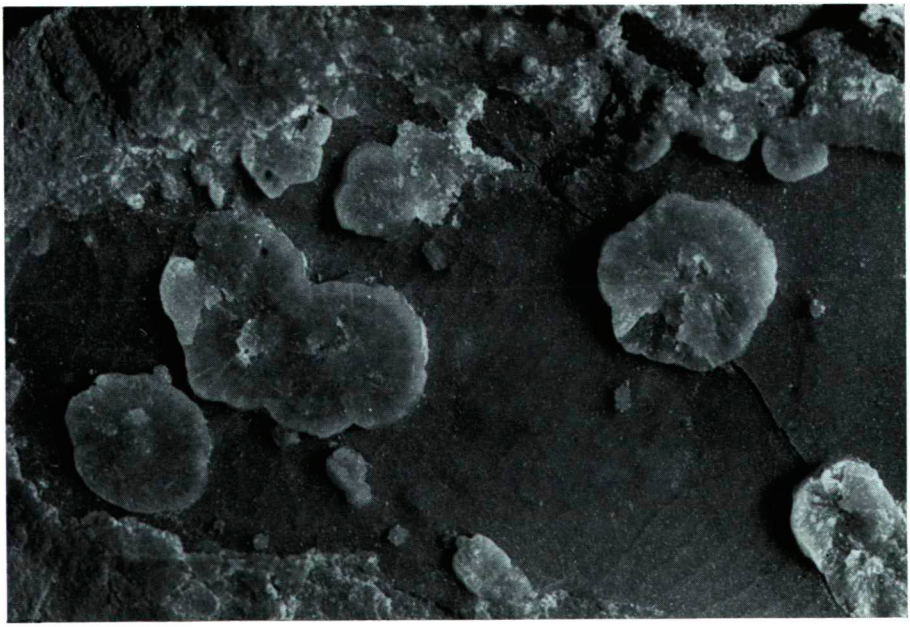

Fig. 2.

Plate II.

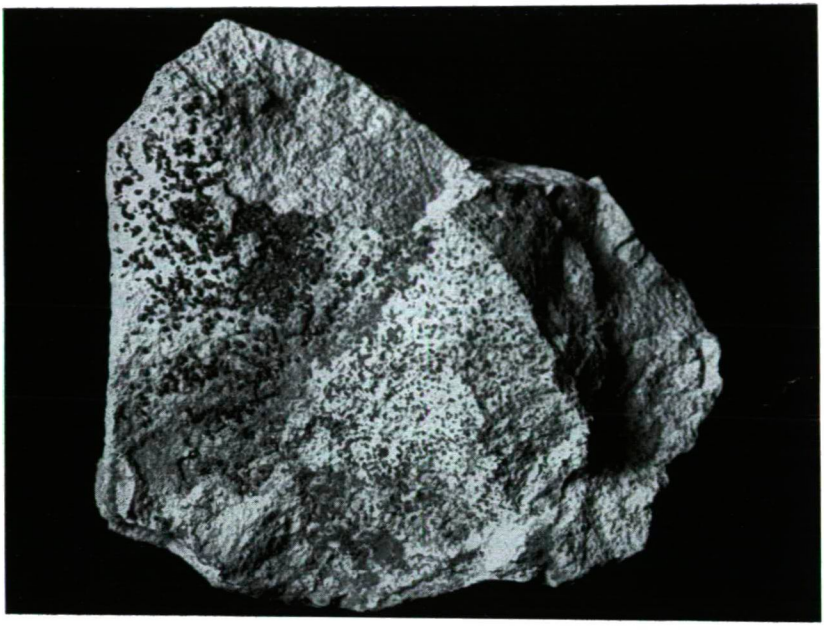

Fig. 1.

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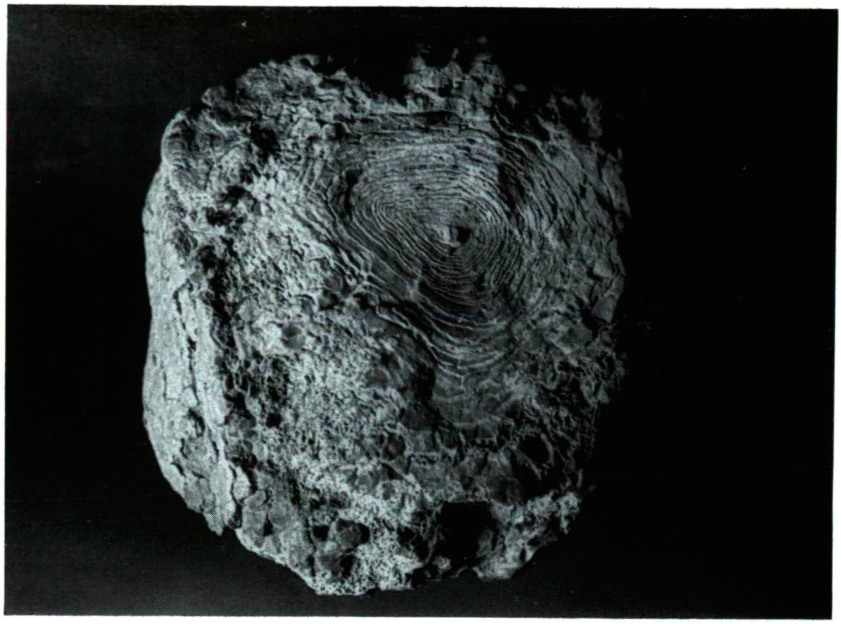

Fig. 1.

Fig. 2.

Plate IV.

Fig. 1.

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Fig. 1.

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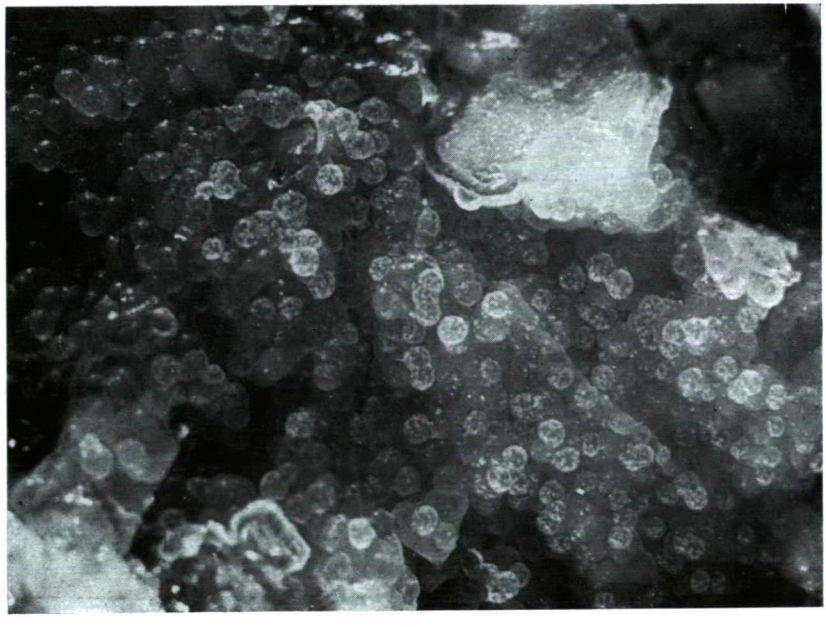
Plate VI.

Fig. 1.



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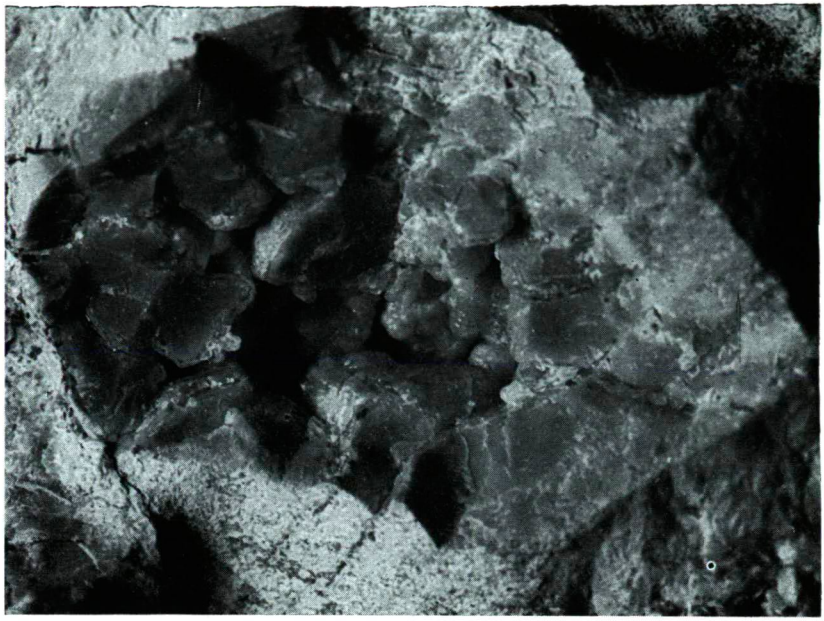

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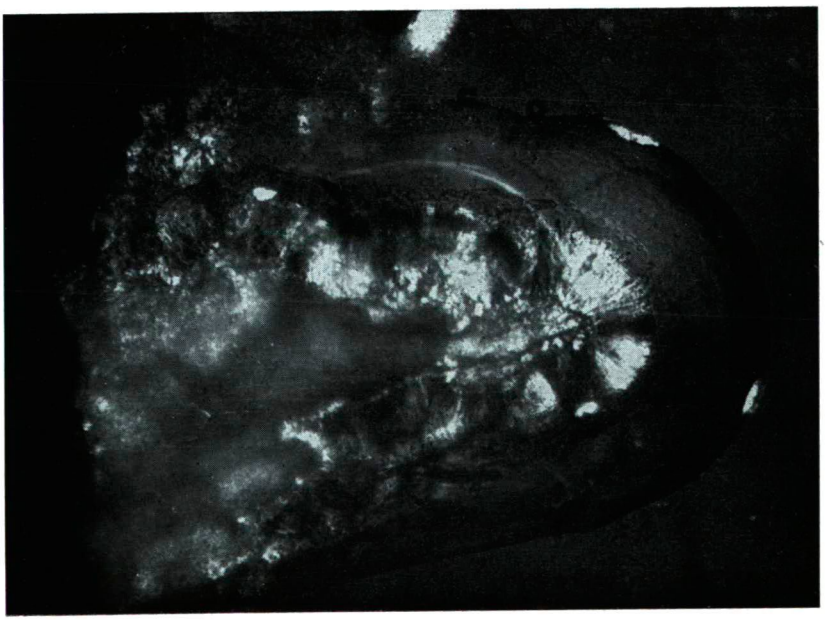

Fig. 2.

DATA ON THE GEOLOGY AND MINERALOGY OF THE MANGANESE ORE DEPOSIT OF URKUT II

J. CSEH NÉMETH
Manganese Ore Mines of Urkut

GY. GRASSELLY
Institute of Mineralogy and Petrography,
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INTRODUCTION

In their previous work [GY. GRASSELLY—J. CSEH NÉMETH, 1961] the authors have dealt with the geology and mineralogy of the most valuable field, i. e. with that of the Slope („Lejtakna") of the manganese ore deposit of Urkut. In order to continue their investigations they intend to describe on similar basis the further fields of the manganese ore district to be able to give a comprehensive picture of the deposit from geological and mineralogical viewpoint.

The field of the Slope is situated in the E part of the manganese oxide ore district at present known. On the SW part of the district lies the field of the shaft No. II extending to W uninterruptedly but in carbonateous development. The area is structurally strongly disturbed in his S boundary and the prospecting points to strongly denuded area poor in exploitable ores. The exploration of the field of the shaft No. II began in 1941 and since then is continually produced.

On the E boundary of the shaft No. II ranges essentially a denudation-zone but in one part the uninterrupted deposit crops out where the open cut mining of „Bocskorhegy" (Mt. Bocskor) has been opened in 1959 and still in work.

The field of the shaft No. III is situated between the field of the Slope and the area of carbonateous development. Essentially it may be divided into two fields, i. e. into northern and southern, respectively, as these fields are separated owing to the denudation. The northern field remained in the field of a syncline, whereas the southern area is the continuation of the manganese bed of the Slope, dipping uniformly in W direction. The two fields of the shaft No. III on the W are interrupted by a big re-accumulated zone and between this zone and the field of carbonateous development already mentioned follows again a manganese ore field of layered development. This field — named also deep level area — is structurally the continuation of the field of the shaft No. II but the two parts are thrown with about 100 m-s level difference along the Csinger-fault. The area of the shaft No. III has been worked since 1953.

In the southern part of the area, i. e. in the field of the "Kövestábla" smaller autochtonous oxide bed has been explored by recent prospecting whose detailed knowledge is the aim of further examinations.

The location of the areas mentioned is shown in *Fig. 1.*

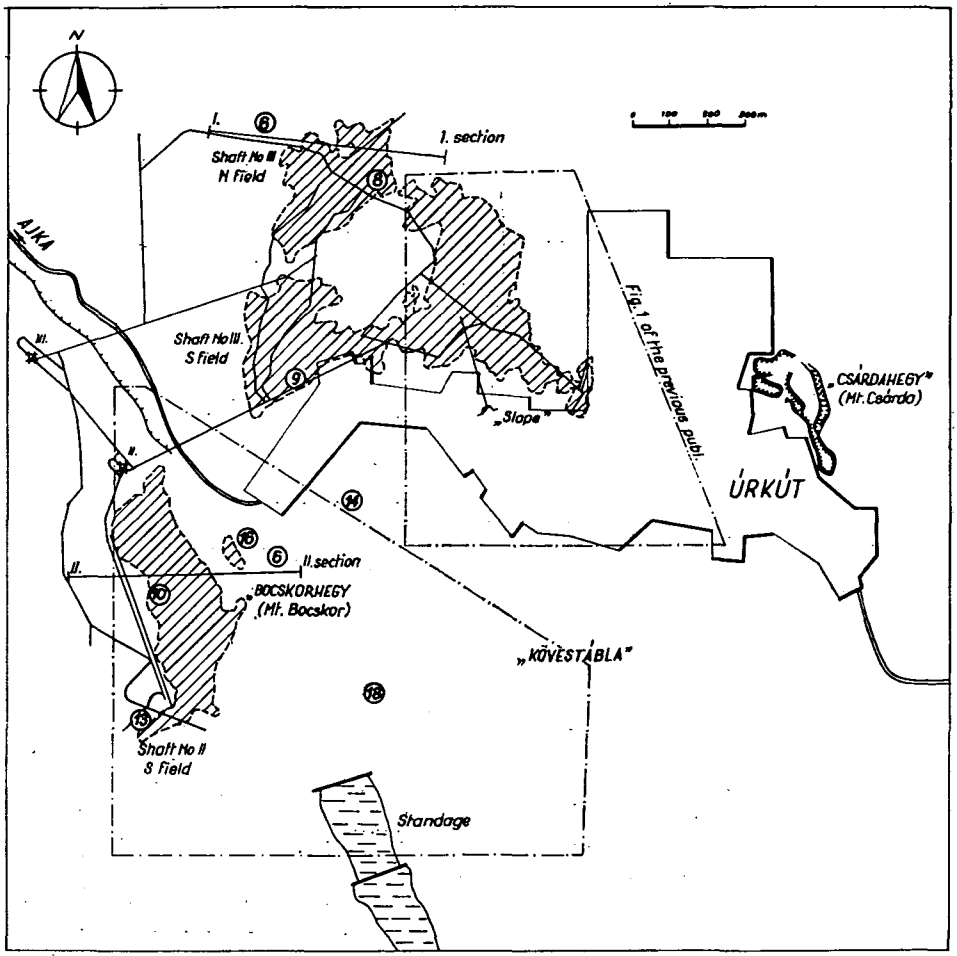


Fig. 1. Sketching geological map of the manganese ore district of Urkut showing the locations of the sections discussed in the present and in the previous work. The numbers in circles mark the corresponding *Figs.* in the text.

THE GEOLOGICAL STRUCTURE OF THE AREAS

In the geological structure of the areas investigated is of fundamental characteristic that in the capping of the manganese beds everywhere Cretaceous layers are deposited whereas in the field of the Slope only the Eocene can be found. So, he denudation, oxidation and re-accumulation of the manganese series in the area nvestigated is limited only to the Pre-Cretaceous era.

Lower Liassic: in the Lower Liassic rhynchonellian cherty limestone, in some places crynoideal limestone can be found. These Lower Liassic rocks have been reached merely in some places of the area discussed, first of all in the explored field of the "Bocskorhegy" and of the "Kövestábla". Connecting to these areas on the surface still lower Liassic layers are frequent.

Middle Liassic: it is represented by red, pinkish cherty limestone, red nodular limestone as well as by clay with cherty streaks in the underlying basement. The cherty limestone is leached in the greater part of the area, firstly in the northern and southern territory of shaft No. III and its relict, the chert-flour, is very frequent.

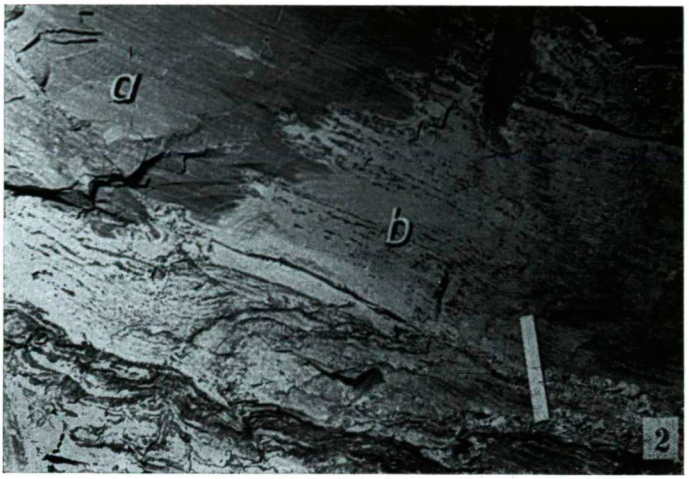


Fig. 2. Alteration and transition, respectively, of dark gray radiolarian clayey marl (*a*) into yellow radiolarian clay (*b*). Shaft No. II.

Fig. 3. Re-accumulated (reworked) manganese series, manganese ore, chert and limestone fragment. N field of the shaft No. III.

In other areas the Middle Liassic rocks are often re-accumulated and in these cases the Middle Liassic is represented by clay series with chert debris of greater thickness.

Upper Liassic: in the area investigated the manganese carbonate ore remained in patches, the oxidized manganese beds as well as the dark gray radiolarian clayey marl in the capping of these and the yellow radiolarian clay formed by the alteration of the latter belong to the Upper Liassic. These rocks may be found in their original places merely in smaller parts of the area, mostly they are re-accumulated, even sometimes traceless denuded.

The thickness of the oxidized ore bed in the areas discussed is generally 2—3 m reaching the 5—6 m thickness only in some places of the "Bocskorhegy". The smaller manganese carbonate ore patches to be found in this field represent transition zones too, inasmuch pure carbonate ore beds are to be seldom established, as the oxidation has already been started in some part of the bed. In the territory of "Kövestábla" the manganese oxide ore is present in two beds separated from each other by yellow radiolarian clay of larger thickness.

Dogger: on the W boundary of the manganese oxide ore field, i. e. on the western border of the shaft No. II and in the deep level field of the shaft No. III, a more completely developed Jurassic sequence can be found. The ore is everywhere of carbonateous development and on the carbonate ore series a chert bank of 0,3—0,5 m in thickness is situated, thereupon a brown, 3,0—5,0 m thick ammonitic marl is deposited turning into thick, green, cherty calcareous marl. The ammonitic marl — on the basis of his fauna — is still Upper Liassic (Toarcian) whereas the green, cherty calcareous marl belongs to the Dogger. The underlying manganese carbonate series was protected by this cover from the devastation as well as from the oxidation. Oxidation of smaller degree can be found merely in some places along tectonical lines.

Cretaceous: at the end of the Jurassic, during the New-Kimmerian orogenetic movements, the structural unity so far of the manganese ore fields is broken down and a considerable devastation is started. The oxide ore territories will be partly reworked, reaccumulated, so in these fields the Cretaceous starts with re-accu-

Fig. 4. Manganese oxide ore (*b*) overfaulted onto manganese carbonate bed (*a*) in the transition zone of the shaft No. II, where the Dogger can already be found in the capping.

Fig. 5. Re-accumulated oblique-layered, detrital capping series in the open cut mining of the „Bocskorhegy".

mulated rocks. These rocks have been built up at first from broken fragments of the manganese ore bed, later different fragments, e. g. chert and limestone debris, respectively, are mixed to them.

In the further part of the Cretaceous, dark gray carbonaceous clay (Aptian), gray nodular limestone is deposited turning gradually into yellowish-white requiaenian limestone (Albian). The latter becomes into western direction thicker and reaches the maximal thickness of 150 meters.

Eocene: the area of the shaft No. III is covered beside the Cretaceous also by Eocene rocks among them in the Lower Eocene by carbonaceous clay and in the Middle Eocene by nummulitic limestone. Eocene formations in the field of "Bocskorhegy" and "Kövestábla" and of the shaft No. II can only in insignificant patches be found.

Pleistocene: the area is covered by sandy loess in patches of 1,0—5,0 m in thickness.

THE DEVELOPMENT OF THE MANGANESE OXIDE ORE BEDS

Sector of shaft No. III: in the northern part of this field the manganese oxide bed generally reaches 2,0—3,0 m. In the lower part of the manganese ore series generally brown clay with manganese patches of 0,5—0,7 m thickness is deposited, whereon fine-bedded manganese oxide ore follows. The layers are mostly very uniform in the bed of shaft No. III, thicker ore banks or nodules can seldom be found. On the other hand, the oxidized ore types of loose structure are very frequent. In the field there can be found in several places carbonate—oxide ore transition zones, wherein compact manganese oxide ore banks — sometimes thicker than 0,5 m — can be found *("Stückerz")*. In the layered manganese oxide ore bed relicts are frequent maintaining the bedded structure but becoming clayey during the oxidation process.

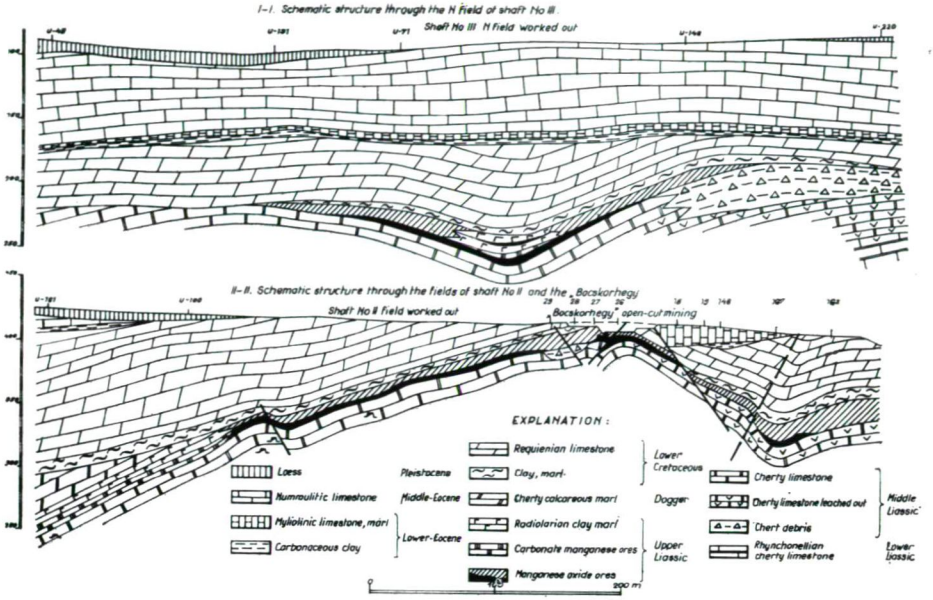


Fig. 6. Geological sections through the fields of the shaft No. III and of the shaft No. II and of the „Bocskorhegy", respectively.

In the cover of the manganese bed phenomena pointing to oxidation and other alteration, respectively, are frequent, as shown in *Fig. 7.* Where the oxidation had already been started, often can be noted that the upper part of the bed becomes gradually loose and clayey.

Fig. 7. Yellow radiolarian clay altered due to oxidation of the manganese bed. The fissures are filled with manganese oxide. The sample originates from the „*a*" layer shown in *Fig. 9.* Shaft No. III.

The section of the north and south field of the shaft No. III — as shown in *Fig. 8* and *9* — is such an area wherein in the lower part the carbonateous ore development is still to be found. It can be stated that the almost 2 m thick carbonate bed is impoverished in manganese content more than in average, on the other hand that the manganese content in the overlying loose, layered manganese oxide ore fluctuates at random, even within the same layer. In the yellow radiolarian clay explored 5—10 cm thick manganese oxide streaks can be seen.

In the eastern boundary of the areas of shaft No. III in the bed there can often be found autochtonous parts thinning out replaced by coarse — fine — detrital manganese layers, finally after 10 m or more breadth they too turn into denuded areas. In some places — in the vicinity of chute No. 4 — the "muddy" manganese oxide beds of considerable thickness are frequent representing the average quality of the original manganese bed and they consist of the completely ground material of the original manganese beds.

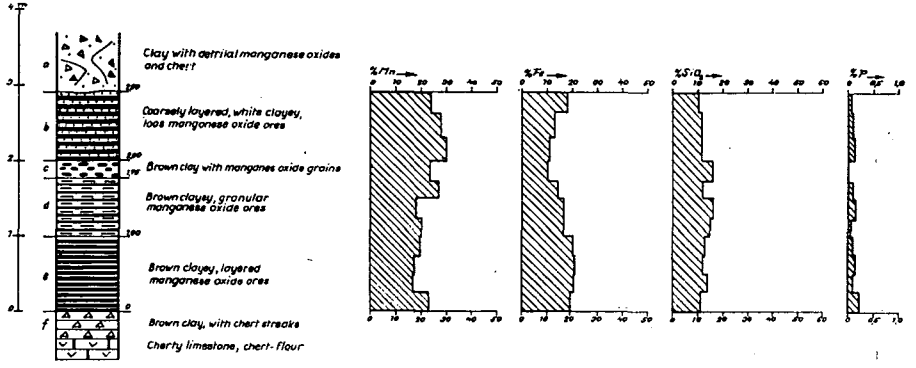


Fig. 8. Section of the ore bed and the distribution of the Mn, Fe, SiO_2 and P content therein. N field of the shaft No. III (+275).

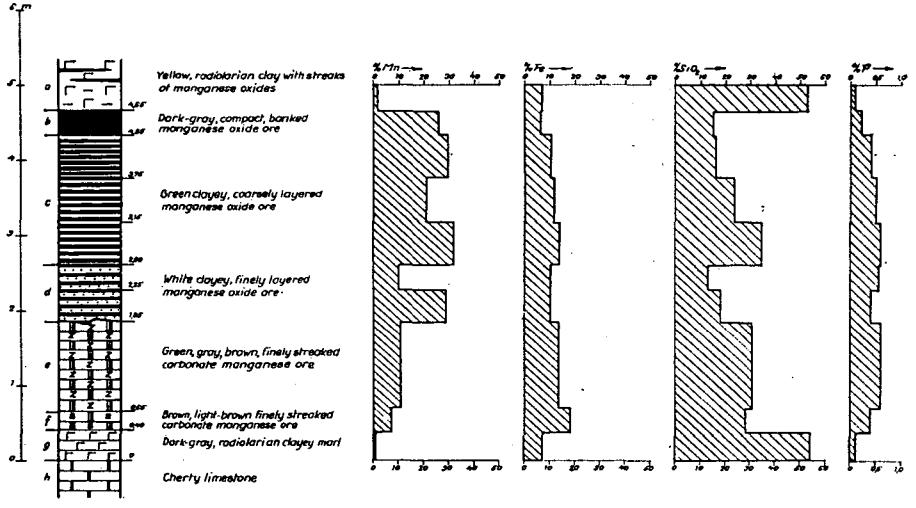


Fig. 9. Section of the ore bed and the distribution of the Mn, Fe, SiO_2 and P content therein. S field of the shaft No. III (+315), transitional zone.

The development of the manganese oxide ore bed of the deep level area of the shaft No. III on the basis of exploratory boring seems to be similar to the development of the manganese bed of the shaft No. II discussed later.

Sector of shaft No. II: the most uniformly developed area of the manganese ore district was the field of the shaft No. II. In the western border of this field there is a manganese carbonate ore bed of 8,0—10,0 m in thickness. This bed thinned out gradually toward east and in the exploitation border of to-day, through a transition zone, turns into a totally oxidized bed.

The oxidized manganese bed consists of manganese oxide ore types of different structure in accordance with the original carbonate ore types. This recognizable character, however, more and more vanishes moved away from the transition zone presumably owing to surface-effects and a more increased oxidation, respectively. This feature is shown in *Fig. 10* by the section of principle. Therein is seen how the different carbonateous layers pass into adequate oxidized ones among them into manganese oxide layers of different structure.

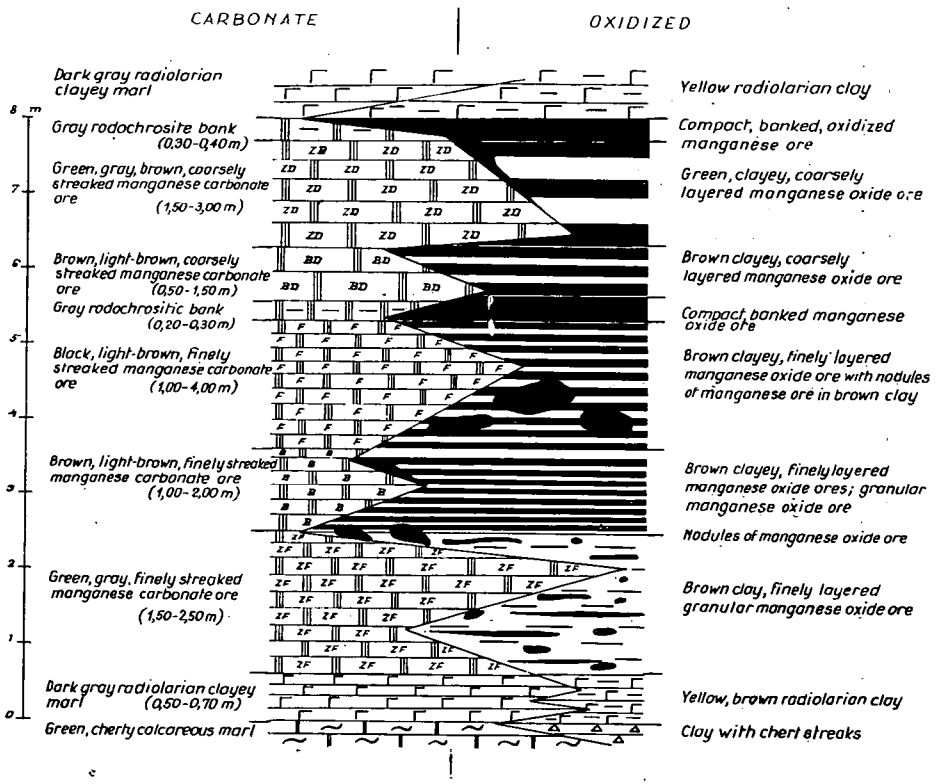


Fig. 10. Section of principle at the edge of the shaft No. II showing the effect of oxidation.

In the bottom of the bed, dark gray radiolarian clay is settled in a thickness of 0,50—0,70 m turning into yellow — gray clay during the oxidation as visible in *Fig. 2.* Thereupon green-gray fine-banded carbonate ore follows, 1,50—2,0 m in thickness from which brown clay with manganese grains and streaks, respec-

tively, is formed. In the boundary of carbonate — oxide ores, manganese oxide nodules are frequent as seen in *Fig. 11.*

On the fine-banded, green, gray manganese carbonate ore, manganese carbonate layers of similar appearence but light brown in color are settled in 1,0—2,0 m thickness. During the oxidation from these layers brown argillaceous, fine-banded manganese oxide ore, granular manganese ore, rarely layers with minute manganese oxide nodules are formed. In the middle of the bed black- light brown, fine — banded manganese carbonate ore is deposited 1,0—2,0 m in thickness containing, beside the rodochrosite, manganese oxides too. From these types are formed due to the oxidation the brown, argillaceous fine-banded manganese oxide

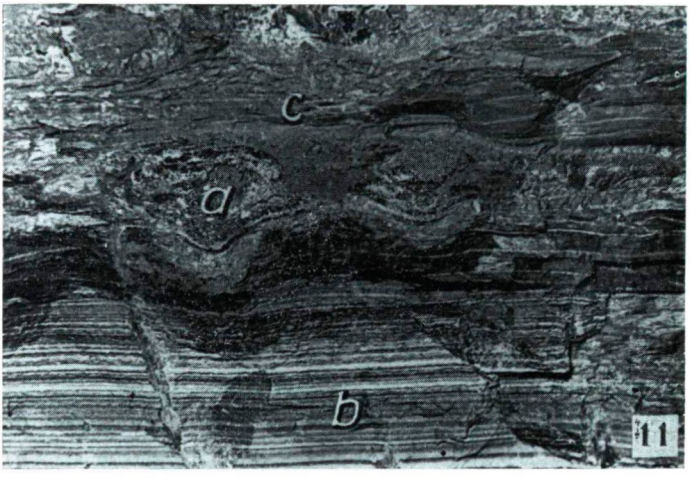


Fig. 11. Manganese oxide nodules (*a*) in the boundary of green, gray fine-layered manganese carbonate ore (*b*) and of manganese oxide ore (*c*). Shaft No. II.

Fig. 12. Manganese oxide bank (*a*) oxidized from black, carbonate ore with remnant of the latter (*b*).

layers wherein manganese nodules, often reaching 1,0 m, are frequent. Within these nodules relicts of the manganese carbonate ore — meanwhile becoming argillaceous — can be found as it is seen in *Fig. 12.* On the black carbonate layers gray rodochrositic layer is settled 0,2—0,3 m in thickness, from which compact, banked manganese oxide ore is formed during the oxidation.

In the upper third of the bed there are coarse-banded manganese carbonate ore types. The thickness of these brown—light brown ores ranges between 0,50—1,50 m. During the oxidation they turned into brown, argillaceous, coarse-banded ore, however, the oxidized manganese ore types of loose structure are also frequent.

In the upper part of the bed green — gray coarse-banded manganese carbonate ore is deposited forming due to later oxidation mainly green argillaceous coarse-bedded manganese oxide ore. Along the boundary of the manganese carbonate and of the oxide ores consequently a compact oxide ore bank — 0,3—0,5 m thick — is situated.

The manganese carbonate bed is covered by gray rodochrositic bank of 0,3—0,4 m in thickness forming during the oxidation also a compact oxide ore bank.

In the capping of the manganese carbonate bed there is a dark-gray, banked, radiolarian clayey marl wherein, however, rarely manganese carbonate streaks can be noted. These resulted in yellow radiolarian clay and oxide streaks, corresponding to the adequate manganese carbonate ones, respectively.

In the transition zones, as a rule, the oxidation has begun in the upper part of the bed and has gradually increased toward east. It is to be mentioned that the continuity of the beds in the southern part of the shaft No. II is limited to smaller areas due to strong tectonical movement, a uniform development can only be established in smaller continuous areas. The capricious disintegration of the bed renders difficult the identification and gives problems in the exploitation. The characteristics of the bed of the shaft No. II is demonstrated by *Fig. 13.*

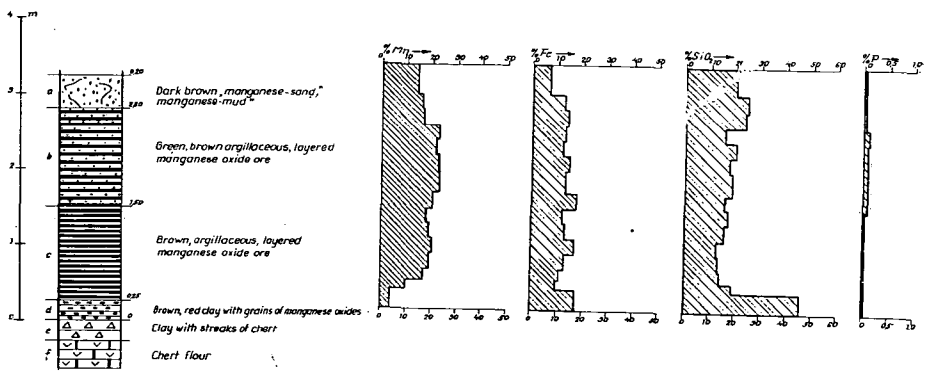


Fig. 13. Section of the bed and the distribution of the Mn, Fe, SiO_2, P content therein. Shaft No. II, borehole U-164.

"*Bocskorhegy*": The manganese bed of shaft No. II gradually rises to the surface and along the Csinger-fault it crops out in the caving where this anticline structure has been opened up in the last years. The manganese bed of this area is learned in details. The development of the bed is shown in *Fig. 14* and the view of the open

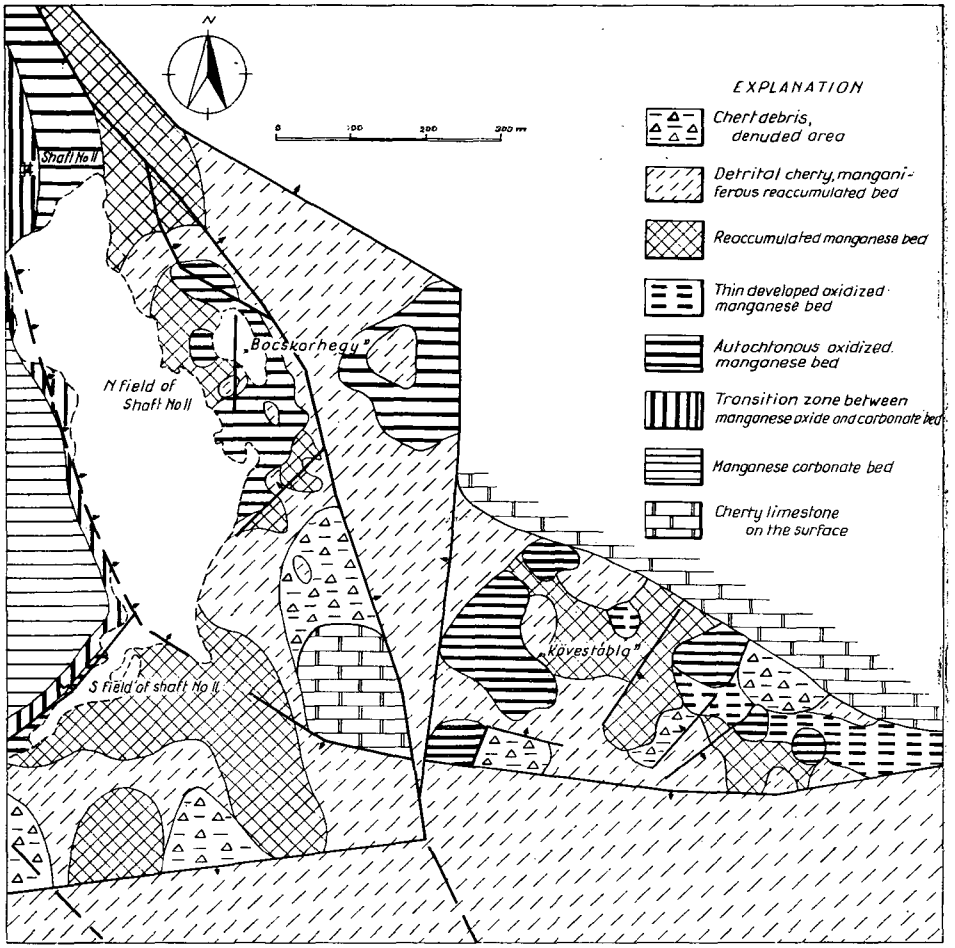


Fig. 14. Sketch of the ore-development on the fields of shaft No. II, „Bocskorhegy" and „Kövestábla", respectively.

cut mining of the "Bocskorhegy" is shown in *Fig. 17.* The development of the bed is essentially similar to that of the shaft No. II only in the chemical composition, firstly in the essential decrease of the P content, there reveal minor differences. The thickness of the beds are nearly the same but in the "Bocskorhegy" re-accumulated interbeddings are frequent *(Fig. 15).* The pecularities of the bed of "Bocskorhegy" are shown by the section in *Fig. 16.*

"*Kövestábla*": in the "Kövestábla", i. e. in the continuation of the open cut mining of the "Bocskorhegy", along complicated structural lines in smaller area autochtonous manganese ore can be established, mostly re-accumulated before the Cretaceous. According to the development of this area also originally there had existed a thinner manganese carbonate bed here and there with double-bed development as mentioned above.

Fig. 15. Layered manganese oxide bed interrupted by a re-accumulated part in the open cut mining of the „Bocskorhegy".

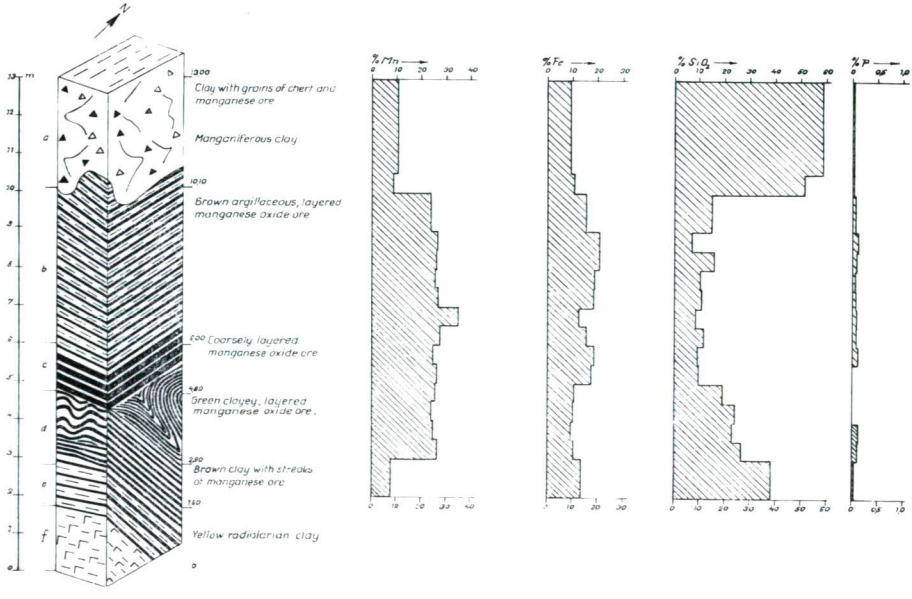


Fig. 16. Section of the exploratory shaft of the „Bocskorhegy" and the distribution of the Mn, Fe, SiO_2 and P content therein.

Fig. 17. View of the open cut mining of the „Bocskorhegy".

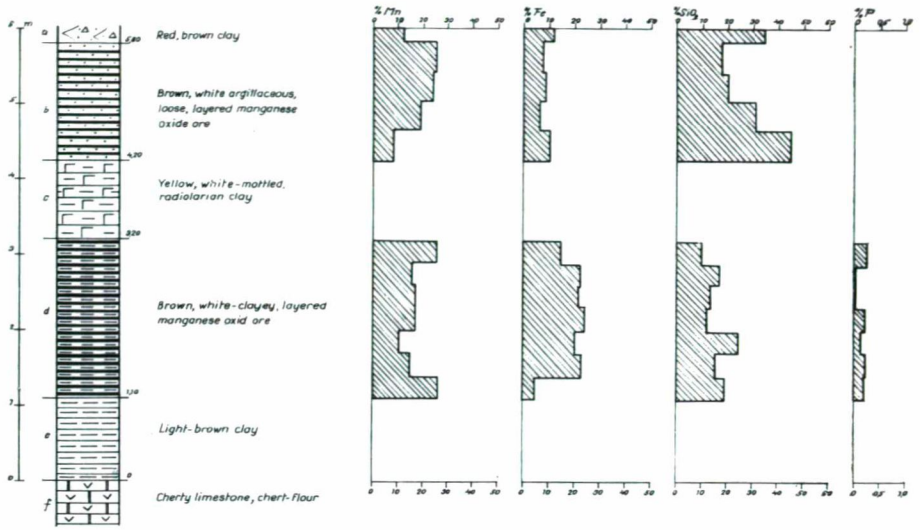


Fig. 18. Section of the bed and the distribution of the Mn, Fe, SiO_2 and P content therein. „Kövestábla", borehole K-72.

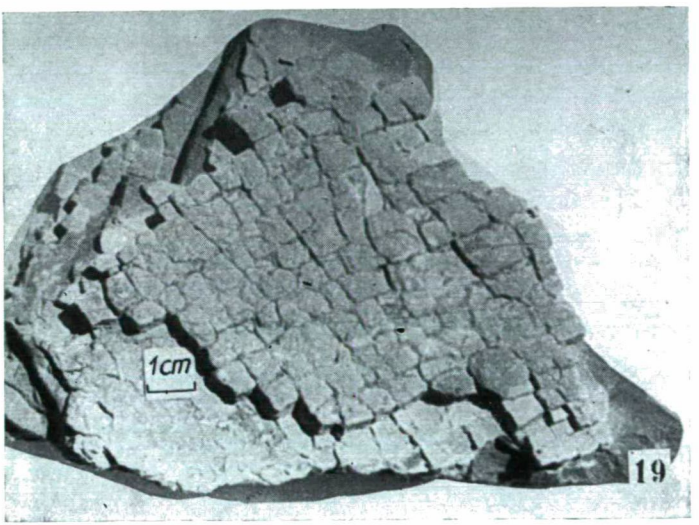


Fig. 19. Sample of manganese carbonate ore showing the rhombohedral cleavage, collected from the Slope.

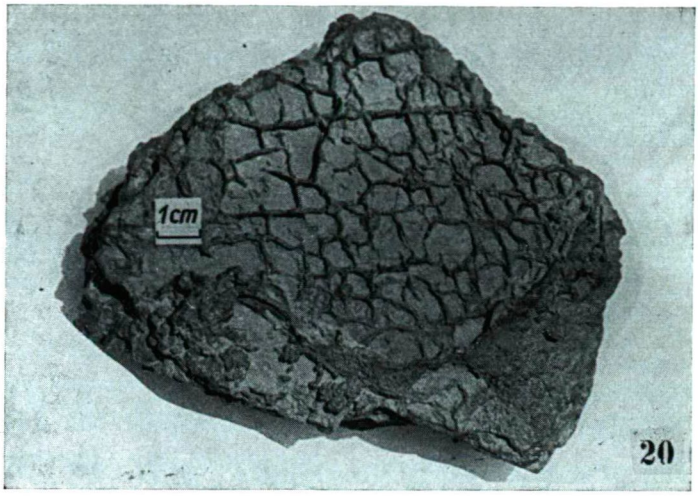


Fig. 20. Fissures according to cleavage direction filled by manganese oxide during oxidation. Collected from the „Kövestábla".

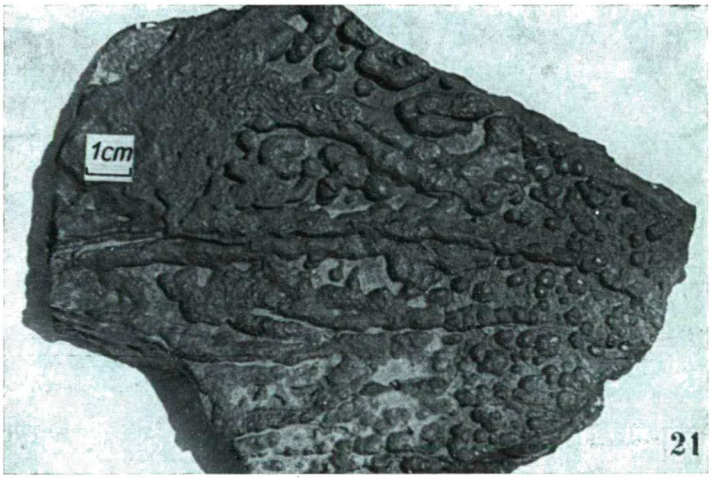


Fig. 21. Surface of an oxidized cleavage plane. Collected from the „Kövestábla".

The carbonate bed croped out in the western part of the anticline of the "Kövestábla" — as can be seen in *Fig. 1* of the pertinent previous publication of the authors — is oxidized, banked and bedded. The oxidation often proceeds along the rhombohedral cleavage planes of the original manganese carbonate ore as seen in *Fig. 20*, The reticulation along the cleavage is well visible in the sample shown in *Fig. 19.* however, without any detectable oxidation. Along the planes of the oxidized layers there can often be found also globular — vesicular surface indicating to colloform formation shown in *Fig. 21.*

THE MANGANESE OXIDE MINERALS OF THE ORES

The mineral composition of the ores of the areas investigated is fairly monotonous and essentially is like the mineral association of the ores of the Slope. However, a fact and an assumption, respectively, is worth mentioning. As it has been already mentioned in our previous work about the geology and mineralogy of the Slope, the manganite in the ores of Urkut occurs more frequently than the average, stated in the literature. In the field investigated, especially in the transition zone between carbonate and oxide ores, *the manganite is relatively very frequent.* It occurs as cavity filling in coarse-grained crystal aggregates within the stubby prisms show a rhytmical, zonal arrangement *(Fig. 22).* Sometimes the manganite forms radiated aggregates built up from larger crystals, which aggregates are surrounded by a band of smaller manganite crystals of mosaic structure *(Fig. 24).* Then and there the cavity is filled by manganite crystals arranged at random *(Fig. 23).* It forms often veinlets filling fissures in the cryptocrystalline cryptomelane — pyrolusite matrix formed earlier. These fissures are often produced by shrinkage of the earlier colloidal material due to the loss of water.

The crystals within the manganite veinlets form sometimes irregularly arranged aggregates or they are symmetrically grown into the fissures from its both sides and the little open space in the middle of the veinlet is often filled later by chalcedony.

The replacement of manganite by pyrolusite can well be observed in many polished ore sections as for example in *Fig. 25,* where the replacement of the manganite crystals embedded in fine crystalline matrix consisting of cryptomelane and pyrolusite, is already started. Under higher magnification also within the single manganite crystals minute pyrolusite veinlets and patches, respectively, are seen.

For the sake of supporting the ore microscopical observations also the *differential thermal analysis* of some of the samples in question was carried out. The samples for the DTA were taken from the polished ore sections investigated microscopically.

At the identification of the manganite by DTA the problem may arrise that iron oxides as the lepidocrocite and goethite have their characteristic endothermic peak between the same temperature interval as the manganite itself, that is, between 300—400 °C.

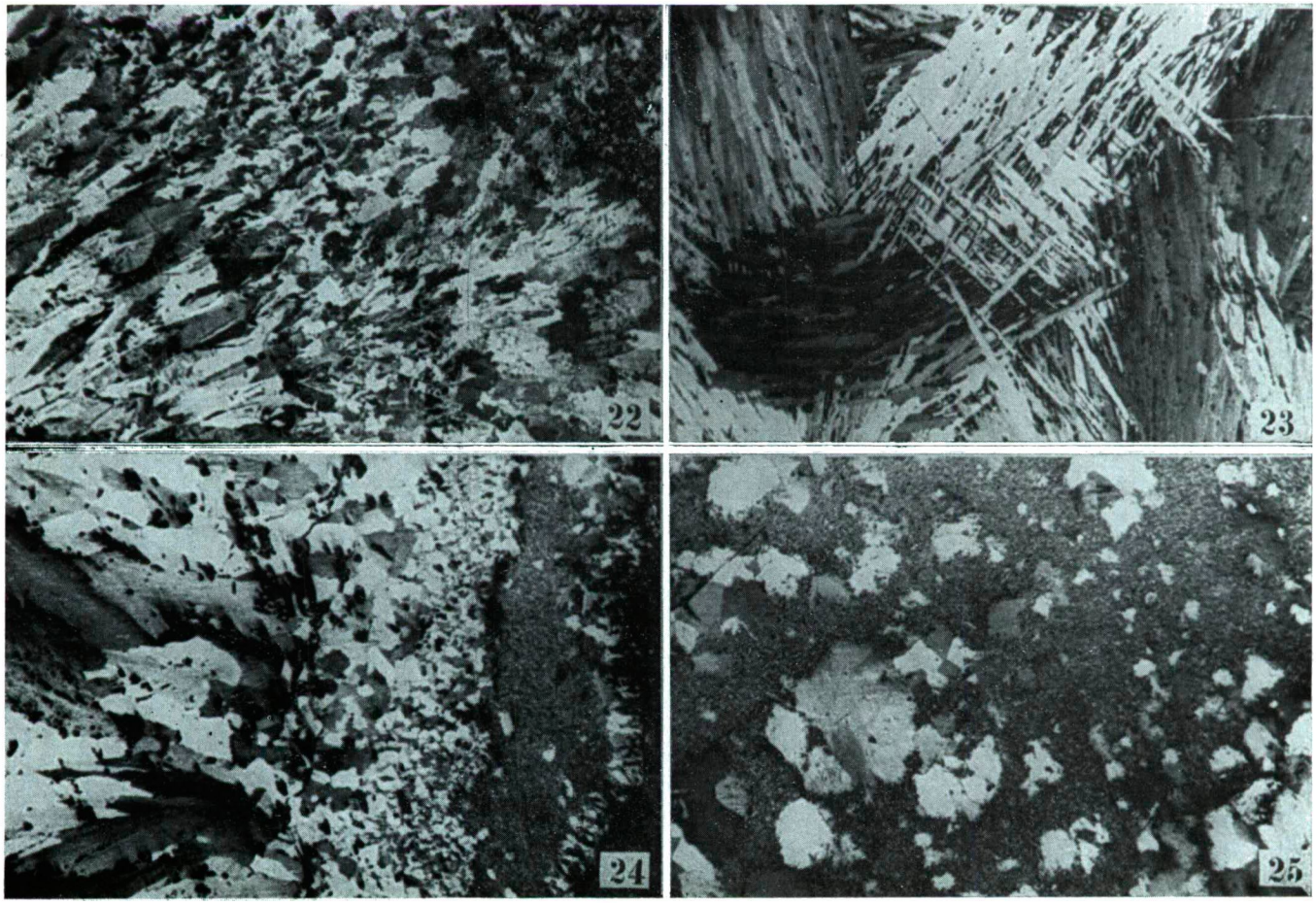
Therefore, DTA curves were made for comparison from two "limonite" samples. One of them originates from Urkut and was taken from a limonitic crust of a manganese ore concretion. The other sample (compact, radiated) was admixed to manganite in a ratio of 5—10—20 per cent. In addition, the iron content of some samples investigated by DTA was also been determined and taken as if it were present as FeOOH. The DTA curves of the "limonite" samples and those of the mixtures, respectively, show that partly the characteristic endothermic peak of

Fig. 22. Cavity filling consisting of aggregate of rhythmically, zonal arranged manganite crystals. Crossed nicols, ×68.

Fig. 23. Crystal aggregate of manganite. Crossed nicols, ×68.

Fig. 24. Manganite as cavity filling. On the left greater columnar manganite crystals, right from the middle aggregate of smaller manganite crystals of mosaic structure, right very fine-grained pyrolusite with cryptomelane: the cavity is bordered by a rim of manganite crystals. Crossed nicols, ×68.

Fig. 25. Manganite crystal remnants in fine-grained pyrolusite-cryptomelane groundmass. The manganite crystals are already partly replaced by the pyrolusite. Crossed nicols, ×136.



Figs. 22—25.

the "limonite" samples is at somewhat lower temperature than that of the manganite partly by decreasing "limonite" content in the mixtures the corresponding peak becomes considerably smaller *(Fig. 38)*. On the other hand, according to the analyses, the iron content of the samples, calculated as FeOOH, does not exceed 14 per cent. Such amount of goethite or lepidocrocite can not result in such pronounced peaks as seen in our DTA curves. Hence, the endothermic peak between 300—400 °C, in accordance with the microscopical observations, indicates the presence of manganite.

The iron content and the corresponding FeOOH content, respectively, of the samples is as follows:

Sample	Fe ≈ Fe OOH in weight per cent		DTA curve, see in Fig.
Selected material of a small manganite veinlet. Sample No. II/4	4,55	7,23	39/1—b
The same sample but the material is selected from the compact matrix. Sample No. II/4	7,12	11,33	39/1—a
Selected material from a manganite veinlet. Sample No. II/5	0,84	1,33	39/1—d
The same sample but the material is selected from the compact matrix. Sample No. II/5	2,84	4,52	39/1—c
Manganese ore sample with cryptomelane and pyrolusite and manganite. Sample No. II/15	4,39	6,98	39/2—h
Compact, radiated, fibrous aggregate of manganite and MnO_2 modification. Sample No. III/4	trace		40/1—c
Black, oxidized manganese ore sample taken from the carbonateous field of the shaft No. III	8,60	13,68	40/2—d

Figs. 26—28. Fine-fibrous, plumose or fan-like aggregates of a MnO_2 modification in a veinlet of silky luster containing considerable amount of manganite too. Crossed nicols, ×68. The DTA curves of the material of this veinlet and that of the surrounding matrix, respectively, see in *Fig. 39/1 a—b.*

Fig. 29. Colloform bands of cryptomelane bordered in some places by sammetblende. Between the bands later manganite. Plain light, ×68.

Fig. 30. Colloform cavity-filling. The wide, multilayered band is composed largely of cryptocrystalline MnO_2 modification alternating with thinner cryptomelane layers. The numerous cracks presumably resulted due to the shrinkage of the gel-like material. Plain light, ×68.

Fig. 31. Fragments of a multi-layered colloform band consisting of MnO_2 modification and cryptomelane cemented by a ferruginous groundmass wherein minute manganite crystals are embedded. Plain light, ×68.

Fig. 32. Multi-layered cavity-filling consisting of alternating layers of cryptocrystalline MnO_2 modification and cryptomelane. Left it is intersected by a manganite veinlet. At bottom, in the middle, there is also manganite. In top, middle, very poorly polished cementing ferruginous matrix. Plain light, ×68.

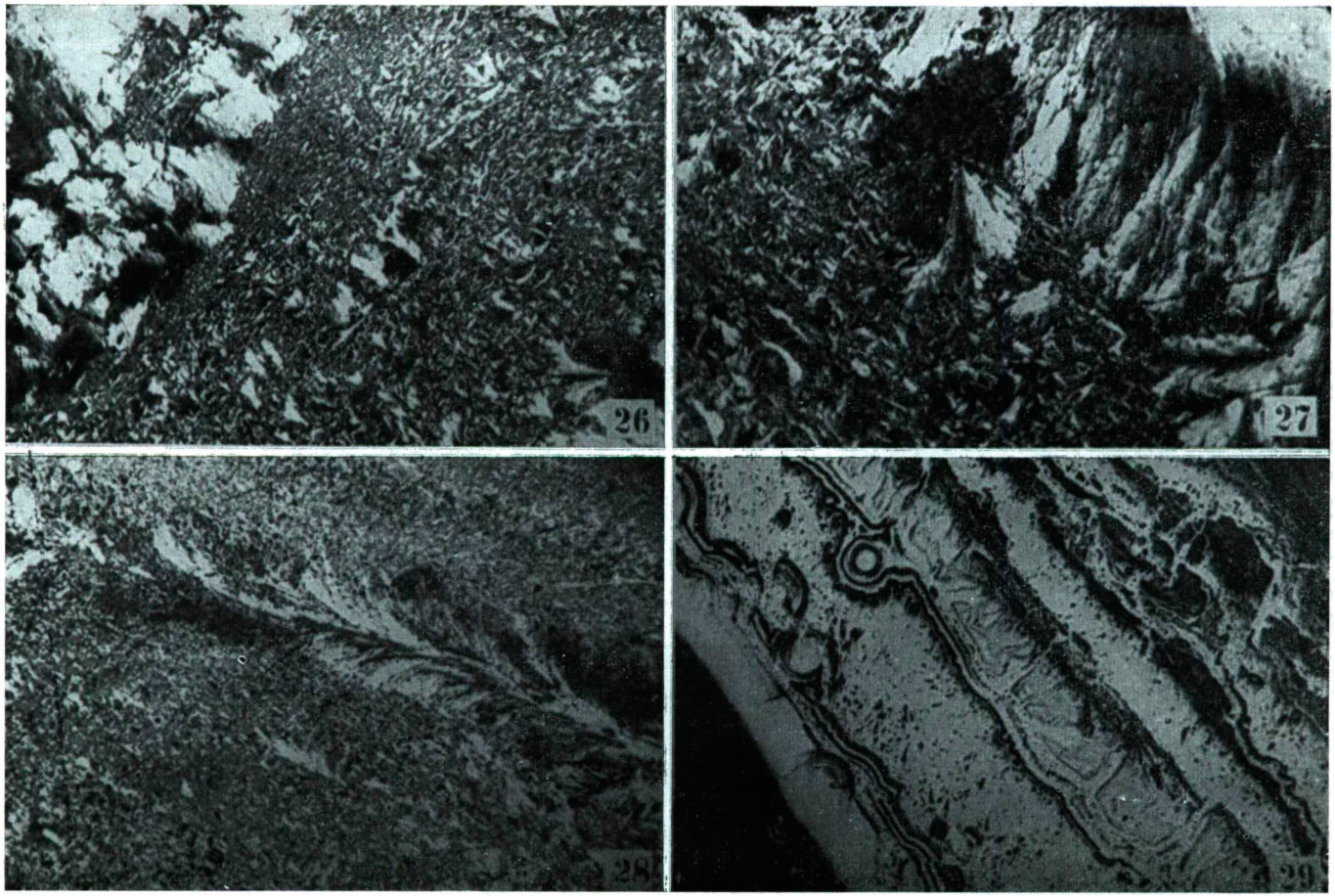
Fig. 33. Colloform, cryptocrystalline cryptomelane in ferruginous matrix. Plain light, ×68.

Fig. 34. Coarse-fibrous pyrolusite crystal aggregate. Crossed nicols, ×68.

Fig. 35. Ferruginous fragments bordered in places by thin interlayered rim of sammetblende and pyrolusite, cemented by poorly polished, felt-like fine-crystalline pyrolusite. Right cryptocrystalline cryptomelane. Crossed nicols, ×68.

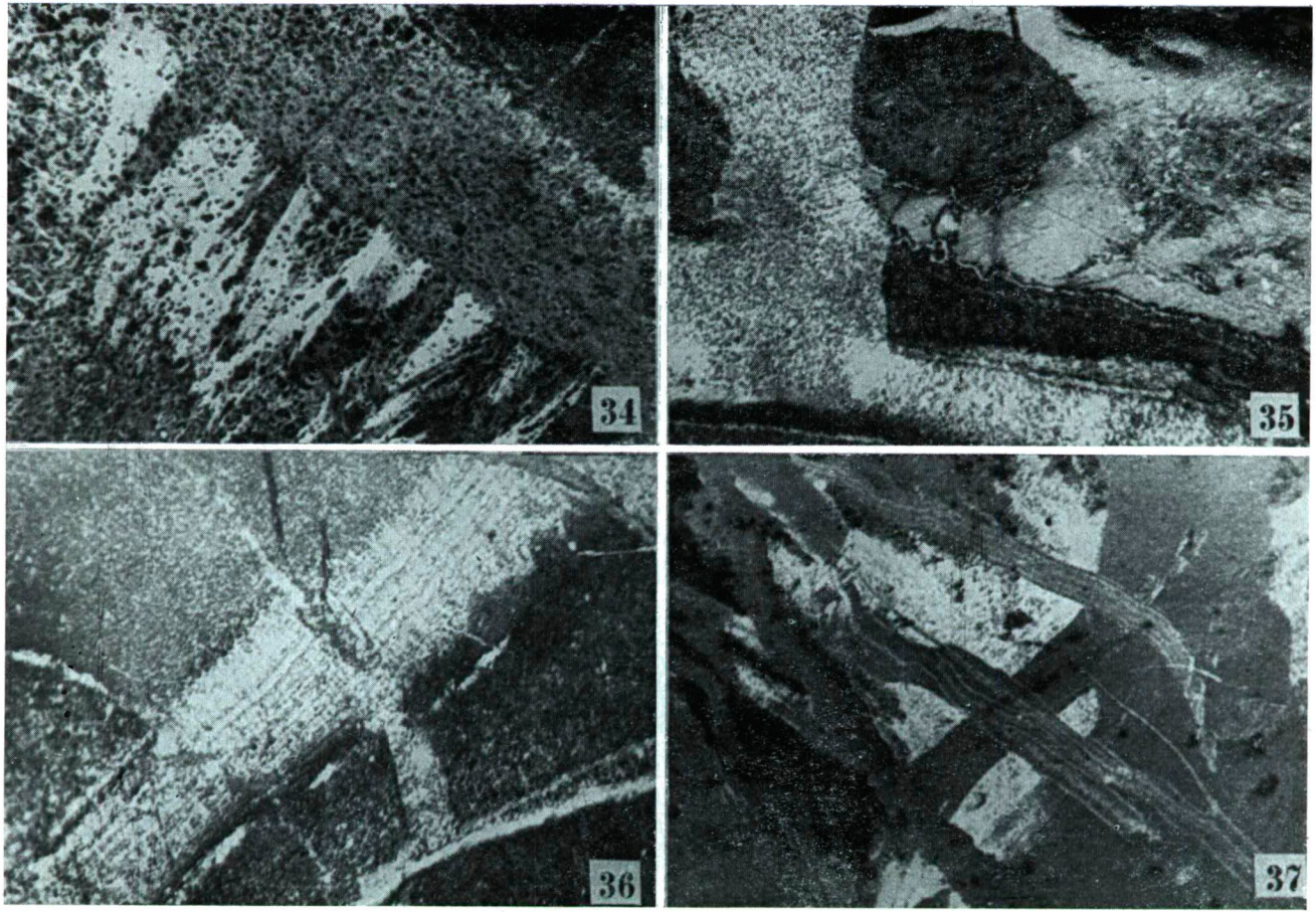
Fig. 36. Cryptocrystalline cryptomelane (in top, left) bordered by interlayered bands of very fine-fibrous pyrolusite oriented arranged and of cryptomelane. Crossed nicols, ×136.

Fig. 37. Very fine-fibrous pyrolusite aggregate and complex symmetrically layered veinlets of similarly fine-fibrous pyrolusite in the groundmass consisting, of cryptomelane. Crossed nicols, ×136.



Figs. 26—29.

Figs. 30—33.



Figs. 34—37.

The DTA curves show a further peculiarity too. Namely, the endothermic peak corresponding to the β-$MnO_2 \rightarrow \alpha$-Mn_2O_3 transformation is not always at about 620—640 °C as it would be in the presence of the most stable β-MnO_2 modification, i. e. in that of the pyrolusite but this peak is at about 600° even at a lower temperature as shown in *Figs. 39—40.* The peak mentioned appears at lower temperatures mostly in samples containing manganite phase too, although the presence of manganite can not be considered as a preliminary condition of the lower temperature of the $MnO_2 \rightarrow Mn_2O_3$ transformation. In samples containing only pyrolusite, with or without manganite, the peak is always over 600 °C. It may be supposed that the presence of manganite may be associated with the appearance of a MnO_2 modification other than pyrolusite which modification would have a lower temperature of transformation. The pyrolusite and the other modification assumed can occur together, For example the DTA curve of a fine-fibrous pyrolusite sample of silky luster from Urkut shows, beside the small manganite peak at about 300 °C, a small endothermic peak at 580 °C and a greater one at 640 °C. The latter corresponds

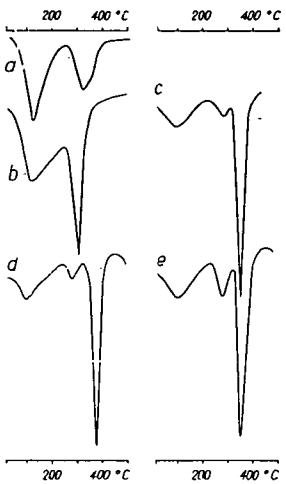


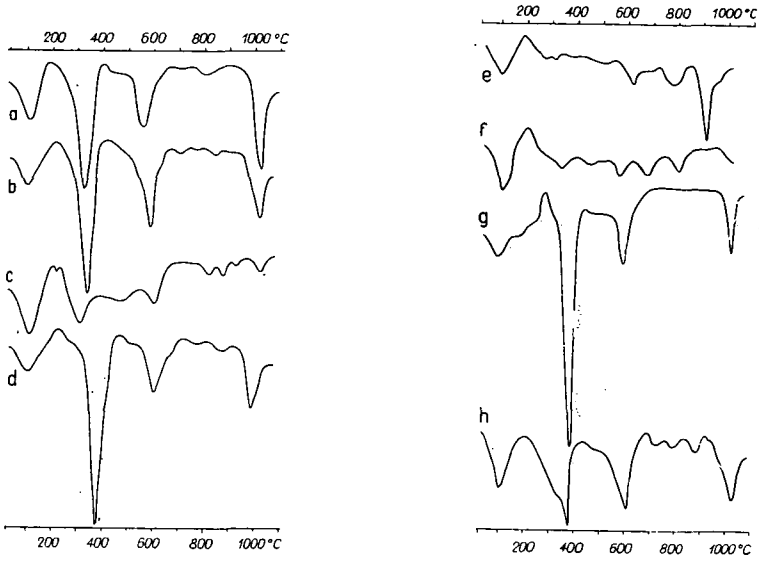
Fig. 38. DTA curves of limonite samples and those of mixtures of limonite + manganite, respectively:
a) Limonitic crust of a manganese ore concretion from Urkut
b) Limonite 100 per cent
c) Limonite 5 per cent — manganite 95 per cent
d) Limonite 10 per cent — manganite 90 per cent
e) Limonite 20 per cent — manganite 80 per cent.

to the pyrolusite, whereas the former may origin from an other MnO_2 modification. *(Fig. 41).*

The question is, the presence of what kind of MnO_2 modification may be supposed. GLEMSER, GATTOW, MEISIEK in their detailed and manysided papers [1960, 1961], concerning the $MnO_2 \rightarrow Mn_2O_3$ transformation, stated that the more disordered was the structure of the MnO_2 modification from which the stable β-modification formed, the lower is the temperature of the transformation. This temperature is — in their opinion — at 620 °C in the case of β-MnO_2 (corresponding to natural pyrolusite), 600 °C in that of the ramsdellite and the transformation of the β-MnO_2 into α-Mn_2O_3 takes place at a still lower temperature (between 500—540 °C) in the case of γ-, η- and δ-MnO_2, respectively.

DTA curves relating to artificial and natural γ-MnO_2 modification can be found in several papers but at present the aim is not to give a comprehensive enumeration of publications dealing with the DTA of the different MnO_2 modifications, merely some of them are mentioned. Thus, for example SOREM and CAMERON as well as ZWICKER et al. dealt with the occurrence of a wide-spread manganese oxid, that of the nsutite and mangano-nsutite, respectively, which may be considered as a natural modification of the γ-MnO_2. The last mentioned authors give the DTA curves of these manganese oxides too. Similarly, SREENIVAS [1957] gives the

DTA curves of an artificial and a natural γ-MnO_2 in his paper. Several DTA curves of different MnO_2 modifications, among them that of the γ-MnO_2 too, are given in the paper of McMurdie and Golovato [1948].



Figs. 39/1 and 39/2. DTA curves of samples taken from the shaft No. II.

a) Sample taken from the compact groundmass of the polished ore section No. II-4.

b) Sample taken from a fine manganite veinlet from the same polished ore section.

c) Sample taken from the compact groundmass of the polished ore section No. II-5.

d) Sample taken from the same polished ore section but from a manganite veinlet.

e) Sample from a compact, breccia-like oxide ore No. II-2.

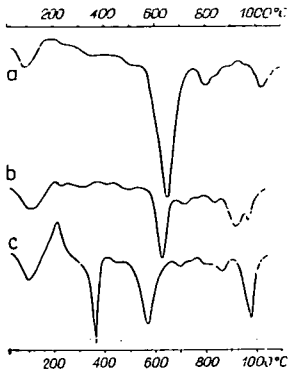
f) Sample taken from a fine-banded, earthy, lustreless ore. Parallel to the banding minute harder veinlets. Polished section No. II/6.

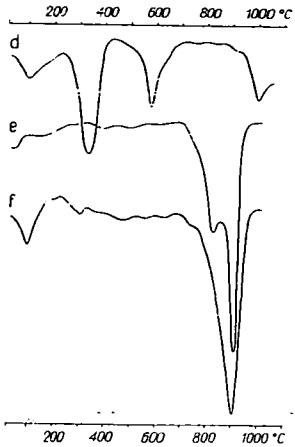
g) Sample taken from a fine-fibrous aggregate of silky luster consisting of manganite and pyrolusite. Polished section No. II/11.

h) Sample taken from a compact, hard, complex ore specimen. Polished section No. II/15

According to the referring works and our own DTA curves it may be supposed that the samples — the DTA curve of which shows an endothermic peak at a lower temperature than 600 °C — beside the pyrolusite or instead of pyrolusite perhaps contain an other MnO_2 modification. These samples contain mostly also manganite and are formed from manganese carbonate due to oxidation. This MnO_2 modification supposed to be other as pyrolusite is in polished ore sections sometimes extremely fine-fibrous, forming fan-like or plumose, frostwork-like aggregates showing a characteristic undulatory extinction.

Naturally, the DTA and the microscopical investigation alone are not sufficient for accurate identification of the MnO_2 modification supposed to be a subvariety of possible γ-MnO_2. Its presence in the ores of Urkut is to be proved by further X-ray investigations.





Figs. 40/1 and 40/2. DTA curves of samples taken from the shaft No. III.

a) Sample taken from the compact, crystalline part of the polished section No. III/1.

b) Sample taken from the same polished section but from in other, fine-grained, compact part.

c) Sample taken from polished section No. III-4. Rhytmically arranged, radiated, fibrous aggregate of manganite and MnO_2.

d) Black, oxidized sample from the neighbourhood of carbonate and manganoan calcite, resp., shaft No. III. carbonate field.

e) Pinkish, crystalline manganoan calcite from the carbonate field of the shaft No. III.

f) Black, poorly layered nodule from the shaft No. III. Sample No. III/2.

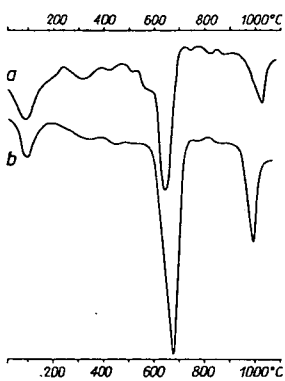


Fig. 41. DTA curves of pyrolusite samples

a) fine-fibrous pyrolusite of silky lustre (Urkut)
b) Coarse-grained pyrolusite as fissure-filling (Urkut—Csárdahegy).

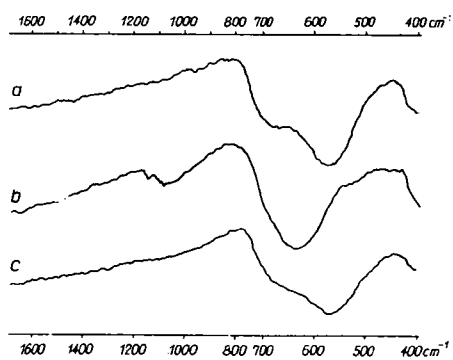


Fig. 42. Infrared absorption spectra of pyrolusite samples

a) Pyrolusite from Ilmenau
b) Fine-fibrous pyrolusite having silky lustre (DTA curve of this sample see in Fig. 41/a.)
c) Coarse-grained pyrolusite (DTA curve of this sample see in Fig. 41/b).

Still, to have assumed its presence as a probability, certain circumstances played a role:

a) the microscopical picture of some of our polished ore sections bears undoubtedly resemblance to the microphotos in the papers of SOREM and CAMERON [1960] as well as in that of ZWICKER et al [1962], respectively.

b) The results of the DTA relating to the artificial and natural γ-MnO_2 modification, available in the literature, and our own DTA curves show a close agreement as to the temperature of the characteristic endothermic peak.

c) The infrared absorption spectra of a coarse-grained pyrolusite sample from Urkut (Csárdahegy) and of the fine-fibrous pyrolusite having silky luster, mentioned above (on the DTA curve of which an endothermic peak is at 580° close before the peak of the pyrolusite), considerably differ as shown in *Fig. 42.* For comparison, the infrared absorption spectrum of a pyrolusite sample from Ilmenau considered as a standard is also given.

d) The MnO_2 modification supposed to be different from pyrolusite occurs mostly associated with manganite and in ores formed from manganese carbonate due to oxidation.

ZWICKER et al. [1962] point to the fact that the proximity to carbonate ores is characteristic of the occurrence of nsutite. They suppose that it is among the first manganese oxides along the birnessite formed due to oxidation from manganese carbonate. In their opinion the nsutite may be formed in slightly alkaline environment and its formation is afforded by contact of manganese carbonate with oxygen-rich water.

The conditions in the manganese district of Urkut, especially in the transition zone between carbonate and oxide, at the rim of the shaft No. II, are particularly suitable.

It is also to mention that E. NEMECZ [1962] ascertained by X-ray investigations the presence of manganite in the black manganese carbonate ore of Urkut.

Assumably the further examinations may clarify the identity of the MnO_2 modification in question.

The *cryptomelane* is also fairly frequent in the oxide ores. In general it is cryptocrystalline having often colloform structure pointing to the formation from gel. Sometimes it is intimately intergrown and/or interlayered with fine-fibrous or similarly cryptocrystalline pyrolusite or with the MnO_2 modification mentioned *(Figs. 30—33, 36, 37).* It occurs often as cavity-filling or impregnating the ferruginous groundmass. The layered, colloform cryptomelane aggregates are sometimes coming apart along the layers at the edges presumably owing to the shrinkage due to the loss of water of the gel-material and the cavity formed between the layers are filled with later manganite *(Fig. 29).* Manganite veinlets intersecting the colloform cryptomelane can also often be observed *(Figs. 30 and 32).* The signs of the later reaccumulation of the original ore beds can sometimes also be observed in the polished ore sections. The fragments of earlier manganese ores are embedded in ferruginous cement *(Fig. 31)* or vice versa, ferruginous fragments are cemented by cryptocrystalline cryptomelane and/or pyrolusite *(Fig. 35).*

The *pyrolusite* forms sometimes coarse-grained aggregates or it is coarse-fibrous or it appears in cryptocrystalline aggregates alone or together with cryptomelane or forms in the latter very fine-fibrous, oriented veinlets interlayered with cryptomelane or forms patches consisting of aggregate of unoriented very fine fibres. *(Figs. 34—37.)*

In most of the polished sections investigated amorphous ferruginous groundmass impregnated with manganese oxides can be observed, *sammetblende* often is seen as thin border and its appearance point to formation from colloidal state. In carbonate ores as thinner or thicker veinlets of fissure-filling is often seen the whitish—slightly pinkish *manganoan calcite* too, the DTA curve of which is shown in Fig. *40/2*.

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KURZER ÜBERBLICK ÜBER DIE PALYNOLOGISCHEN ERGEBNISSE AUS DEM PRAEQUARTÄR UNGARNS MIT BESONDERER BERÜCKSICHTIGUNG DER STRATIGRAPHISCHEN STELLUNG DES URKUTER MANGANERZES

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Die im Laufe der vergangenen Jahre durchgeführten palynologischen Untersuchungen haben zahlreiche Einzelfakten über ungarische Sporomorphen-Gemeinschaften aus verschiedenen Altersstufen und Lokalitäten erbracht. Sie waren der Anlaß, diese Ergebnisse in großen Zügen zusammenfassend auszuwerten. Diese Zusammenfassung bemüht sich, die bisher aufgeschlossenen Sporomorphengemeinschaften nach dem neuesten Stand der Kenntnisse so gut wie möglich altersmäßig einzustufen. Sie weist andererseits auf das teilweise noch unvollständige Wissen und damit auf die vor der ungarischen Palynologie stehenden zukünftigen Aufgaben hin.

Der leichteren Verständlichkeit wegen wurden die Ergebnisse in einer Tafel zusammengefaßt. Die Tafel wurde in erster Linie nach den Angaben aus der publizierten Literatur zusammengestellt. Wir waren bestrebt, die charakteristischsten und vom faziesökologischen sowie stratigraphischen Gesichtspunkt aus bedeutungsvollsten Typen auszuwählen, Die Abbildungen wurden dagegen von Typusexemplaren angefertigt. In der Tafelerklärung sind die Namen der Autoren und das Erscheinungsdatum der Arbeiten aufgezeichnet, von denen wir die Daten übernahmen. Im Literaturverzeichnis wurden ausschließlich die Veröffentlichungen über die ungarischen praequartären und die damit im engen Zusammenhang stehenden rezenten Daten aufgenommen. Bei dieser Zusammenstellung strebten wir nach Vollständigkeit. Das Literaturverzeichnis schließt mit dem Jahre 1965. Im Manuskript begriffene Arbeiten werden nur zitiert, wenn Vergleichsmaterial für die Tafel aus ihnen verwendet wurde.

Der vorläufig älteste Pollenkomplex Ungarns stammt aus dem oberen Perm und wurde durch STUHL [1961] bekannt gemacht. Er ist vor allem durch altertümliche Luftsackpollen charakterisiert. Als nächst jüngere Gemeinschaft dürfte diejenige von Solymár einzuschätzen sein (KEDVES 1965 c). Sie steht im Grenzbereich vom Perm zur Trias, kann aber evtl. die untere Trias zum Teil noch mit umfassen.

Eine Verbindung zwischen diesen beiden Komplexen läßt sich anhand des bisherigen Materials noch nicht herstellen. Auch in der letztgenannten Pollen-

kombination sind zahlreiche altertümliche Luftsackpollen zu finden, jedoch kommt die für die Trias charakteristische *Unatextisporites (Ovalipollis)* hier schon vor. Jünger als diese oder mit ihr gleichaltrig sind die Sporen-Pollen-Gemeinschaften der Proben von der Bohrung Mesteri I, die JUHÁSZ, KŐVÁRY, KRIVÁN—HUTTER & MAJZON [1964] dort aus dem Teufenabschnitt zwischen 1903—1904 und 1983—1989 m entnommen hatten.

Von den bisherigen klar separiert ist der reiche Komplex der oberen Ladinien-Stufe. JUHÁSZ, KŐVÁRY, KRIVÁN—HUTTER & MAJZON [1964] bestätigten ihn mit Foraminiferen. Zwischen diesem Horizont und einem von VENKATACHALA & GÓCZÁN [1964] ausführlich beschriebenen Komplex aus der oberen Trias bestehen engen Zusammenhänge. Obwohl auf der Tafel nicht vermerkt, sei auf die Anwesenheit von *Circulina* fsp. in der Sporomorphen-Gemeinschaft des oberen Ladinien hingewiesen. In der durch VENKATACHALA & GÓCZÁN [1964] bekanntgemachten Flora aus der oberen Trias sind Angehörige des Subturma *Operculati* ein besonders kennzeichnendes Element. Sie bestätigen, daß sich die interessanten *Gymnospermen*typen des unteren und mittleren Mesozoikums bedeutend vermehrt haben. Es ist bemerkenswert, daß der mit Luftsäcken ausgestattete Typ der *Coniferen*pollen zurückgedrängt wurde.

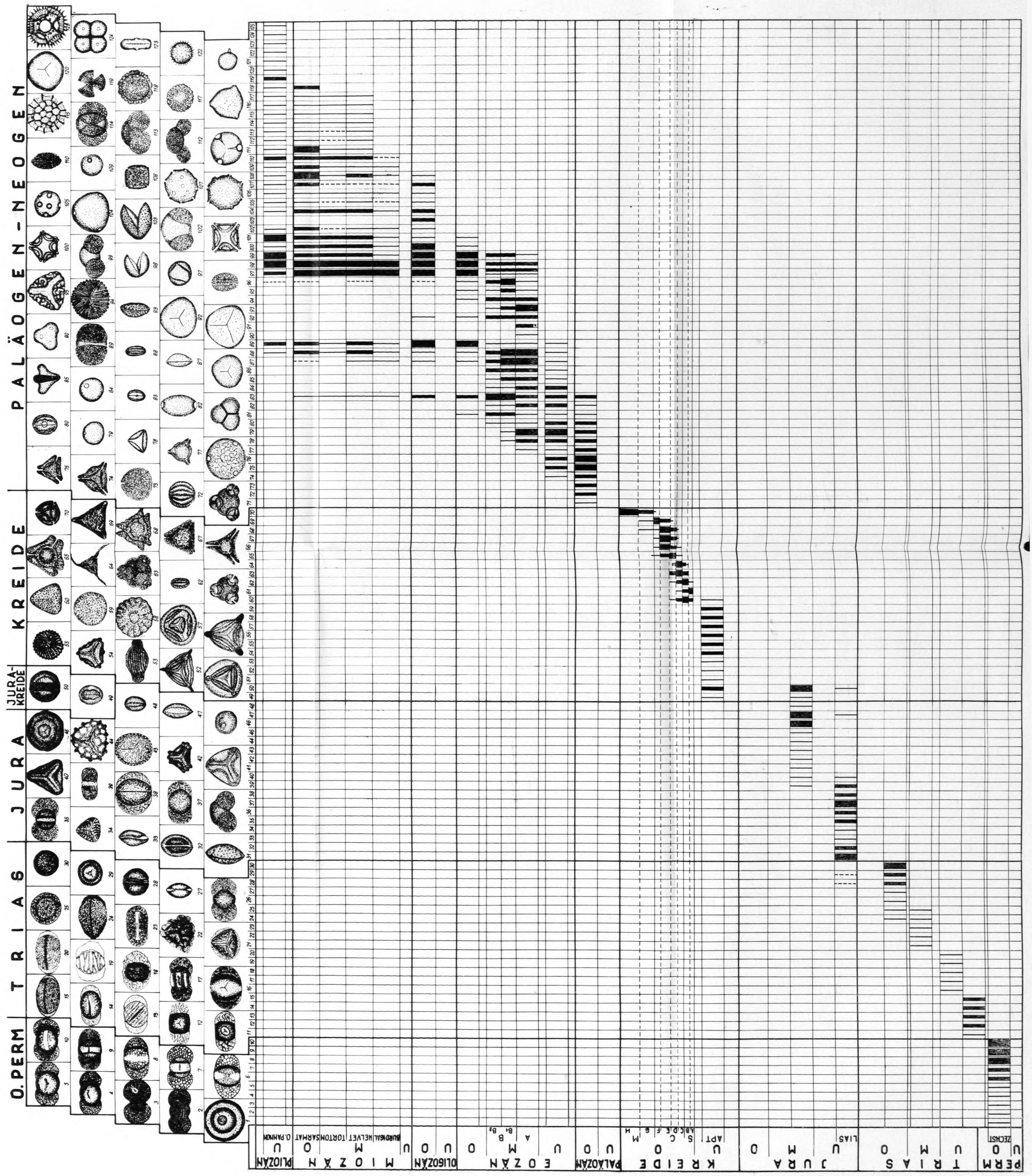
Über die steinkohlenführenden Sedimente aus dem unteren Jura sind in den Arbeiten von GÓCZÁN [1956] und BÓNA [1963] mehrere Angaben bekannt gemacht worden. Bedeutungsvoll ist das Vorhandensein der Pollen des Subturma *Operculati*, obwohl sie hier eine geringere Rolle spielen als in der zuvor erwähnten Pollengesellschaft aus der oberen Trias. Nach ihren Pollen zu schließen, muß im unteren Jura eine mannigfaltige *Gymnospermen*flora existiert haben; denn neben *Cycadales* und *Bennettitales* fallen weitere Luftsackpollen in sehr abwechslungsreichen Erscheinungsformen auf.

Von den bisher genannten Florengemeinschaften läßt sich als dann diejenige aus dem Urkuter Manganerz einwandfrei unterscheiden. Sie war in den mittleren Jura einzuweisen (KEDVES & SIMONCSICS 1964 a). Wiederum ist es der Subturma *Operculati*, der — hier mit der Formgattung *Classopollis* — zu besonderer Entfaltung gelangt. Auch zahlreiche *Pteridophyta*-Sporen sind aus dem Urkuter Manganerz bekannt. Bedeutend ist weiter die ebenfalls große Zahl der *Cycadales*- und *Ginkgoales*pollen.

Unsere Kenntnisse über die Trias und besonders den Jura sind außerordentlich mangelhaft. Auf Grund dieser Tatsache war es bisher noch nicht möglich, bessere als nur spärliche Verbindungen zwischen dem Jura und der unteren Kreide herzustellen. Es ist jedoch zu bemerken, daß die im Komlóer Lias erscheinende und im Urkuter Manganerz massenhaft vorkommende *Classopollis*art nach H. DEÁK [1965] im Tonmergel der Apt-Stufe noch von Bedeutung ist. Die Sporen-Pollen-Zusammensetzung der Apt-Stufe von Ungarn ist sehr gut bekannt und muß in Zukunft als Grundkomplex behandelt werden. Jetzt ist es das starke Auftreten charakteristischer, abwechslungsreicher *Pteridophyta*-Sporen sowie das der *Welwitschiapites*, *Araucariacites*, *Inaperturopollenites*-Arten und weiterer *Gymnospermen*-Typen, welches hier das Gesamtbild entscheidend bestimmt.

Die auf die obere Kreide bezüglichen Angaben sind aus mehreren Arbeiten von GÓCZÁN bekannt. Die Angaben auf der Tafel wurden von uns aus der Veröffentlichung von GÓCZÁN [1964 b] mit der ausführlichen Originalgliederung übernommen. Dieser Komplex ist noch nicht völlig bekannt, so daß z. Z. noch keine Verbindungen zur Kreide und dem Tertiär aufgezeigt werden können. Als wichtigste

O.PERM | TRIAS | JURA | JURA-KREIDE | KREIDE | PALÄOGEN-NEOGEN



Eigentümlichkeit muß hier der außerordentliche Reichtum an altertümlichen *Angiospermen*pollen *(Normapolles)* gennant werden.

Soweit es die Palynologie betrifft, ist das ungarische Tertiär am besten untersucht. Dennoch werden zukünftige Arbeiten zu einer wesentlichen Erweiterung unserer Kentnisse über fossile Sporomorphen führen und die bisherigen Arbeitsresultate in vieler Hinsicht in ein neues Licht rücken.

Für das Paleogen bilden die zur Publikation vorbereiteten Ergebnisse von Bakony die Grundlage [KEDVES 1965 f). Unter den angegebenen Arten befinden sich auch solche, die erst demnächst veröffentlicht werden. Diese wurden in der Tafelerklärung mit Stern bezeichnet.

Auch für das unterste Tertiär ist die dominierende Zahl der modernen *Angiospermen*pollen charakteristisch, im oberen Paleozän das bedeutende Vorkommen der *Normapolles* und *Postnormapolles.* Im unteren Eozän ließ das Auftreten der *Postnormapolles* nach, obwohl sie noch immer bemerkenswert sind. Bedauernswert, daß zwischen den Komplexen des unteren und mittleren Eozäns die Lücke ziemlich groß ist. Das geht auch deutlich aus einigen auf der Tafel abgebildeten Typen hervor.

Das bakonyer mittlere Eozän ist sehr leicht zu gliedern. Im allgemeinen sind tropische Elemente besonders häufig. Ihre Zahl geht dann in der obersten Zone des mittleren Eozäns ein wenig zurück. Zum Übergang von der obersten Zone des mittleren Eozäns und dem bisher bekannten oberen Eozän verfügen wir über keine Daten. Die wichtigste Eigentümlichkeit ist das bedeutende Auftreten der subtropischen Elemente, welche die Grundlage für die sich später entwickelnde neogene Flore bilden.

Den Übergang zwischen dem Eozän und dem Oligozän kennen wir ebenfalls nicht. Die vorher erwähnten subtropischen Elemente vermehren sich weiter und vermischen sich mit ausgesprochen gemäßigten Elementen. Als typische, im oberen Neogen beginnende Florenelemente würden wir die Gattungen *Picea, Liquidambar, Pterocarya* und *Juglans* bezeichnen.

Als Grundlage für das Miozän nahmen wir die Arbeit von SIMONCSICS [1963] für die speziellen Verhältnisse des oberen Pannons die von E. NAGY [1958]. Allgemein sehr charakteristisch für die Flora des Neogens ist das häufige Vorkommen der *Taxodiaceen-* und *Cupressaceen*pollen, welche schon im oberen Eozän ihren Anfang nahmen. Die Verminderung oder der Mangel der paleogenen Formen sowie das Vorkommen modernerer Arten in späterer Zeit ist außerordentlich auffällig. Unter den letzteren sind auch die Pollen mehrerer Kräuter. Die Abtrennung der einzelnen Teile des Miozäns wird mit der eingehenden Untersuchung der Pollen der entwickeltsten *Angiospermen* ganz sicher vervollkomnet werden können.

Der Übergang zwischen dem Miozän und dem Pliozän ist gleichfalls unbekannt. Im oberen Pannon setzte sich die Vermehrung der phylogenetisch jüngsten Typen der Pflanzenwelt fort (E. NAGY 1958). Vorläufig ist uns das Einsetzen der *Compositae, Umbelliferae* und von *Typha* erst von hier an bekannt. Hinsichtlich der Entwicklung der *Coniferen* lohnt sich der Hinweis, daß sich in der sogenannten neogenen Flora etwa vom oberen Eozän an die stufenweise Vermehrung und Differenzierung der mit Luftsäcken ausgestatteten *Coniferen*pollen abgespielt hat. Sie lassen sich schon gut mit den rezenten Genera *Pinus, Picea, Keteleeria, Abies* und *Cedrus* identifizieren.

Wie bereits erwähnt, sind unsere Kenntnisse über diese Zusammenhänge z. Z. noch sehr unvollständig, und es stehen beachtliche Aufgaben vor uns. Aber wir glauben, daß wir in einigen Jahren wesentlich günstigere Voraussetzungen für eine befriedigende Lösung dieser Aufgaben haben werden.

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1 — *Nuskoisporites dulhuntyi* R. POT. & KLAUS 1954 (STUHL 1961), 2— *Lueckisporites richteri* KLAUS 1955 (STUHL 1961), 3 — *Pityosaccus papilionis* R. POT. & KLAUS 1954 (STUHL 1961), 4 — *Jugasporites tectus* LESCHIK 1956 (STUHL 1961), 5 — *Jugasporites perspicuus* LESCHIK 1956 (STUHL 1961), 6 — *Pityosporites zapfei* R. POT. & KLAUS 1954 (STUHL 1961), 7 — *Limitisporites latus* LESCHIK 1956 (STUHL 1961), 8 — *Pityosporites schaubergeri* R. POT. & KLAUS 1954 (STUHL 1961), 9 — *Pityosporites delasaucei* R. POT. & KLAUS 1954 (STUHL 1961), 10 — *Lueckisporites virkkiae* R. POT. & KLAUS 1954 (STUHL 1961), 11 — *Disaccites* gen. & sp. indet. (KEDVES 1965 c), 12 — *Limitisporites* fsp. (KEDVES 1965 c), 13 — Cf. *Striatites* fsp. (KEDVES 1965 c), 14 — *Pallidosporites* fsp. (KEDVES 1965 c), 15 — *Unatextisporites* fsp. (KEDVES 1965 c), 16 — *Illinites purus* LESCHIK 1956 (JUHÁSZ, KŐVÁRY, KRIVÁN—HUTTER & MAJZON 1964), 17 — *Taeniaesporites ortisei* KLAUS 1963 (JUHÁSZ, KŐVÁRY, KRIVÁN—HUTTER & MAJZON 1964), 18 — *Ellipsovelatisporites plicatus* KLAUS 1960 (JUHÁSZ, KŐVÁRY, KRIVÁN—HUTTER & MAJZON 1964), 19 — *Striatites* sp. (JUHÁSZ, KŐVÁRY, KRIVÁN—HUTTER & MAJZON 1964), 20 — *Ovalipollis* sp. (JUHÁSZ, KŐVÁRY, KRIVÁN—HUTTER & MAJZON 1964), 21 — *Camarozonosporites rudis* (LESCHIK 1955) KLAUS 1960 (JUHÁSZ, KŐVÁRY, KRIVÁN-HUTTER & MAJZON 1964), 22 — *Zebrasporites fimbriatus* KLAUS 1960 (JUHÁSZ, KŐVÁRY, KRIVÁN-HUTTER & MAJZON 1964), 23 — *Lueckisporites junior* Klaus 1960 (JUHÁSZ, KŐVÁRY, KRIVÁN-HUTTER & MAJZON 1964), 24 — *Ovalipollis rarus* KLAUS 1960 (JUHÁSZ, KŐVÁRY, KRIVÁN-HUTTER & MAJZON 1964, VENKATACHALA & GÓCZÁN 1964), 25 — *Enzonalasporites tenuis* LESCHIK 1955 (JUHÁSZ, KŐVÁRY, KRIVÁN-HUTTER & MAJZON 1964, VENKATACHALA & GÓCZÁN 1964), 26 — *Podocarpidites* sp. (Venkatachala & Góczán 1964), 27 — *Ginkgocycadophytus nitidus* (BALME 1957) VENKATACHALA & GÓCZÁN 1964 (VENKATACHALA & GÓCZÁN 1964), 28 — *Classopollis classoides* (Pf. 1953 b) POC,. & JANS. 1961 (VENKATACHALA & GÓCZÁN 1964, BÓNA 1963), 29 — *Corollina meyeriana* (KLAUS 1960) VENKATACHALA & GÓCZÁN 1964 (VENKATACHALA & GÓCZÁN 1964, BÓNA 1963), 30 — *Granuloperculatipollis rudis* VENKATACHALA & GÓCZÁN 1964), (VENKATACHALA & GÓCZÁN 1964], 31 — *Cycadinae* sp. (GÓCZÁN 1956), 32 — *Bennettitinae* sp. (GÓCZÁN 1956), 33 — *Ginkgoinae* sp. (GÓCZÁN 1956), 34 — *Zebrasporites* sp. (BÓNA 1963), 35 — *Podocarpaceae* sp. (GÓCZÁN 1956), 36 — *Pinus silvestris*-Typ RUDOLPH (GÓCZÁN 1956), 37 — *Pinus haploxylon*-Typ RUDOLPH (GÓCZÁN 1956), 38 — *Picea* Typ (GÓCZÁN 1956), 39 — *Pityopollenites pallidus* REISSINGER 1940 (GÓCZÁN 1956, SIMONCSICS & KEDVES 1961), 40 — *Toroisporis (Toroisporis) toralis* (LESCHIK 1955) KDS. & SIM. 1964 a (GÓCZÁN 1956, KEDVES & SIMONCSICS 1964 a), 41 — *Toroisporis (Toroisporis) curvitorus* KDS. & SIM. 1964 a (KEDVES & SIMONCSICS 1964 a), 42 — *Concavisporites (Obtusisporis) divisitorus* KDS. & SIM. 1964 a (KEDVES & SIMONCSICS 1964 a), 43 — *Clavatisporites clarus* KDS. & SIM. 1964 a (KEDVES & SIMONCSICS 1964 a), 44 — *Dictyotriletes (Klukisporites) deaki* KDS. & SIM. 1964 a (KEDVES & SIMONCSICS 1964 a), 45 — *Polycingulatisporites circulus* SIM. & KDS. 1961 (SIMONCSICS & KEDVES 1961), 46 — *Spheripollenites subgranulatus* COUPER 1958 (SIMONCSICS & KEDVES 1961, KEDVES & SIMONCSICS 1964 a), 47 — *Monosulcites minimus* COOKSON 1947 ex COUPER 1958 (SIMONCSICS & KEDVES 1961), 48 — *Monosulcites urkutiensis* SIM. & KDS. 1961 (SIMONCSICS & KEDVES 1961), 49 — *Eucommiidites troedssonii* ERDTMAN 1947 (SIMONCSICS & KEDVES 1961, KEDVES & SIMONCSICS 1964 a, H. DEÁK 1965), 50 — *Classopollis torosus* (REISSINGER 1950) COUPER 1958 (SIMONCSICS & KEDVES 1961, BÓNA 1963, KEDVES & SIMONCSICS 1964 a, H. DEÁK 1965), 51 — *Vinculisporites flexus* H. DEÁK 1964 (H. DEÁK 1965), 52 — *Appendicisporites stylosus* (THIERG. 1954) H. DEÁK 1963 (H. DEÁK 1965), 53 — *Welwitschiapites striatus* H. DEÁK 1963 b (H. DEÁK 1965), 54 — *Gleicheniidites umbonatus* (BOLCH. 1953) W. KR. 1959 b (H. DEÁK 1965), 55 — *Cicatricosisporites venustus* H. DEÁK 1963 a (H. DEÁK 1965), 56 — *Plicatella trichacantha* MALJ. 1949 (H. DEÁK 1965), 57 — *Duplexisporites generalis* H. DEÁK 1962 (H. DEÁK 1965), 58 — *Inaperturopollenites undulatus* WEYL. & GREIF. 1953 (H. DEÁK 1965), 59 — *Araucariacites hungaricus* H. DEÁK 1964 (H. DEÁK 1965), 60 — *Microreticulatisporites pseudofoveolatus* H. DEÁK 1964 (H. DEÁK 1965, GÓCZÁN 1964 b), 61 — *Oculopollis orbicularis* GÓCZÁN 1964 b (GÓCZÁN 1964 b), 62 — *Tricolpopollenites sümegensis* Góczán 1964 b (GÓCZÁN 1964 b), 63 — *Oculopollis zaklinskaiae* GÓCZÁN 1964 b (GÓCZÁN 1964 b), 64 — *Appendicisporites tricuspidatus* WEYL. & GREIF. 1953 (GÓCZÁN 1964 b), 65 — *Hungaropollis ajkanus* GÓCZÁN 1964 b (GÓCZÁN 1964 b), 66 — *Extratriporopollenites longianulus* GÓCZÁN 1964 b (GÓCZÁN 1964 b), 67 — *Extratriporopollenites elegans* GÓCZÁN 1964 b (GÓCZÁN 1964 b), 68 — *Extratriporopollenites crassus* GÓCZÁN 1964 b (GÓCZÁN 1964 b), 69 — *Extratriporopollenites lenneri* GÓCZÁN 1964 b (GÓCZÁN 1964 b), 70 — *Trudopollis praesubhercynicus* GÓCZÁN 1964 b (GÓCZÁN 1964 b), 71 — *Oculopollis goczani* KDS. 1965 f * (KEDVES 1965 f), 72 — *Polycolpites viesenensis* W. KR. 1961 d (KEDVES 1965 f), 73 — *Triporopollenites undulatus* TH. & PF. 1953 (KEDVES 1965 f), 74 — *Urkutipollis triangulus* KDS. 1965 f * (KEDVES 1965 f), 75 — *Plicapollis pseudoexcelsus* W. KR. 1958 a (KEDVES 1965 f), 76 — *Subtriporopollenites constans* PF. 1953 a *magnus* W. KR. 1961 d (KEDVES 1965 f), 77 — *Basopollis krutzschi* KDS. 1965 f * (KEDVES 1965 f), 78 — *Interpollis velum* W. KR. 1961 d (KEDVES

1965 f), 79 — *Subtriporopollenites urkuticus* KDS .1965 f * (KEDVES 1965 f), 80 — *Tricolporopollenites parmularius* (R. POT. 1934) W. KR. 1959 d *cylindrior* PF. 1953 a (KEDVES 1965 f), 81 — *Ericipites longisulcatus* WODEH. 1933 (KEDVES 1965 f), 82 — Diporites iszkaszentgyörgyi KDS. 1965 e (KEDVES 1965 f), 83 — *Tricolporopollenites cingulum* (R. POT. 1934) Th. & PF. 1953 pusillus (R. POT. 1934) TH. & PF. 1953 (KEDVES 1965 f, SIMONCSICS 1963), 84 — *Monoporopollenites hungaricus* KDS. 1965 d (KEDVES 1965 f), 85 — *Pentapollenites laevigatus laevigatoides* W. KR. 1962 c (KEDVES 1965 f), 86 — *Leiotriletes microadriennis* W. KR. 1959 b (KEDVES 1965 f), 87 — *Monocolpopollenites tranquillus* (R. POT. 1934) TH. & PF. 1953 *tranquillus* (KEDVES 1965 f, SIMONCSICS 1963), 88 — *Tricolpopollenites liblarensis* (THOMS. 1950) (=*quisqualis* R. POT. 1934) *liblarensis* (THOMS. 1950) TH. & PF. 1953 (KEDVES 1965 f, SIMONCSICS 1963), 89 — *Pityosporites microalatus* (R. POT. 1931 b) TH. & PF. 1953 (KEDVES 1965 f, SIMONCSICS 1963, E. NAGY 1958 b), 90 — *Anacolosidites laevigatus* KDS. 1965 f * (KEDVES 1965 f), 91 — *Leiotriletes maxoides* W. KR. 1962 *palaeogenicus* KDS 1965 f * (KEDVES 1965 f), 92 — *Leiotriletes adriennis* (R. POT. & GELL. 1933) W. KR. 1959 b (KEDVES 1965 f), 93 — *Monocolpopollenites granulatus* KDS. 1961 a (KEDVES 1965 f), 94 — *Cicatricosisporites dorogensis* (R. POT. & GELL. 1933) KDS 1961 a *major* KDS. 1961 a (KEDVES 1965 f), 95 — *Trilites asolidus* W. KR. 1959 b (KEDVES 1965 f), 96 — *Tricolporopollenites margaritatus* (R. POT. 1931 a) TH. & PF. 1953 *medius* PF. & TH. 1953 (KEDVES 1965 f, SIMONCSICS 1963, E. NAGY 1958 b), 97 — — *Inaperturopollenites dubius* (R. POT. & VEN. 1934) TH. & PF. 1953 (KEDVES 1965 f, SIMONCSICS 1963, E. NAGY 1958 b), 98 — *Taxodiaceaepollenites* (al. *Pollenites*) *hiatus* (R. POT. 1931) KREMP 1949 (KEDVES 1965 f, SIMONCSICS 1963, E. NAGY 1958 b), 99 — *Pityosporites labdacus* (R. POT. 1931 b) TH. & PF. 1953 (KEDVES 1965 f, SIMONCSICS 1963, E. NAGY 1958 b), 100 — *Alnipollenites verus* (R. POT. 1931 a) R. POT. & VEN. 1934 (KEDVES 1965 f, KEDVES & URI KISS 1966, SIMONCSICS 1963, E. NAGY 1958 b), 101— *Alnipollenites verus* (R. POT. 1931 a) R. POT. & VEN. 1934 (KEDVES 1965 f, KEDVES & URI KISS 1966, SIMONCSICS 1963, E. NAGY 1958 b), 102 — *Piceaepollenites alatus* R. POT. (KEDVES 1965 f, SIMONCSICS 1963, E. NAGY 1958 b), 103 — *Taxodiaceaepollenites granulatus* KDS. 1965 f * (KEDVES 1965 f),104 — *Caryapollenites* (al. *Pollenites*) *simplex* (R. POT. 1931 b) RAATZ 1937 *simplex* TH. & PF. 1953 (KEDVES 1965 f, SIMONCSICS 1963, E. NAGY 1958 b), 105 — *Liquidambarpollenites* (al. *Pollenites*) *stigmosus* (R. POT. 1931 a) RAATZ 1937 (KEDVES 1965 f, SIMONCSICS 1963, E. NAGY 1958 b), 106 — *Pterocaryapollenites* (al. *Pollenites*) *stellatus* (R. POT. 1931 a) RAATZ 1937 (KEDVES 1965 f, SIMONCSICS 1963, E. NAGY 1958 b), 107— *Juglanspollenites maculosus* (R. POT. 1931) KDS. 1965 f * (KEDVES 1965 f, SIMONCSICS 1963, E. NAGY 1958), 108 — *Ulmipollenites undulosus* WOLFF 1934 (KEDVES 1965 f, SIMONCSICS 1963, E. NAGY 1958 b), 109 — *Monoporopollenites gramineoides* MEYER (SIMONCSICS 1963, E. NAGY 1958 b), 110 — SALIX sp. (SIMONCSICS 1963, E. NAGY 1958 b), 111 — *Fagoipollenites pseudocruciatus* R. POT. (SIMONCSICS 1963), 112 — *Keteleeria* sp. (SIMONCSICS 1963, E. NAGY 1958 b), 113 — *Abiespollenites absolutus* THIERG. (SIMONCSICS 1963, E. NAGY 1958 b), 114 — *Cedripites cedroides* (TH.) R. POT. (SIMONCSICS 1963, E. NAGY 1958), 115 — *Persicarioipollis* sp. (SIMONCSICS 1963), 116 — *Polyporopollenites carpinoides* PF. (SIMONCSICS 1963), 117 — *Sciadopityspollenites serratus* (R. POT. & VEN.) R. POT. (SIMONCSICS 1963, E. NAGY 1958 b), 118 — *Tsugaepollenites* spp. (SIMONCSICS 1963, E. NAGY 1958 b), 119 — *Acer* sp. (E. NAGY 1958 b), 120 — *Intrabaculisporis magnus* KDS. & J. R. 1964 (KEDVES & RÁKOSY 1964), 121 — *Cryptomeria hungarica* E. NAGY 1958 b) (E. NAGY 1958 b), 122 — *Nymphaeaceae* sp. LESCHIK (E. NAGY 1958 b), 123 — *Umbelliferae* (E. NAGY 1958 b), 124 — *Typha* sp. (E. NAGY 1958 b), 125 — Cf. *Mulgendium* sp. (E. NAGY 1958 b).

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DATA ON THE EPIGENE ALTERATION OF ANDESITES

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In andesites lacking mafic minerals, i. e. in amafites, under epigene conditions first the magnetite in the matrix is dissolved in places and the microscopical feature of the rock is changed. The originally compact, gray rock becomes mottled. During the weathering, in place of the mottles, minute hollows are formed, filled partly or totally by clay minerals. The colloidal material separates layer by layer which accounts for the layered appearance well discernible under crossed nicols. The clay mineral belongs to the montmorillonite group and it may be considered as a transition member between beidellite and nontronite.

In the Western Mátra Mountains near Szurdokpüspöki in the neighbourhood of mine of Pincepatak there occurs an andesite of very diversified appearance. Beginning from the fresh, unaltered rock the single steps of the clay mineralization can be well noted.

The references dealing with the geological structure of this area refer firstly to the neighbouring diatomite series [H. HORUSITZKY — 1901; J. NOSZKY — 1912; T. SZALAI — 1936, 1949; CHENEVIERE — 1933; F. HORUSITZKY — 1950; Z. SCHRÉTER — 1950; M. HAJÓS — 1954, 1956; HAJÓS—PÁLFALVY — 1959; BÁRDOSSY—HAJÓS — 1960]. Data regarding the eruptive series can be found in the papers of B. MAURITZ [1912], GY. VIGH [1935], J. NOSZKY [1926] and I. KUBOVICS [1965].

In the Upper Tortonian andesite series gray compact andesite occurs as thinner or thicker lava-flow having frequently a streaked appearance *(Fig. 1)*. The lighter streaks — poor in magnetite — are nearly parallel. The streaks and bands suggest often the direction of the flow, in these cases also the microlites show such an arrangement.

The matrix of the rock always predominates wherein porfiric feldspar with cleavage planes of vitreous luster can only be observed in little amount. The porfiric feldspar, 2—3 mm in grain-size, amounts about to 6 per cent. Its appearance is mainly columnar and its composition is between Ab_{40}—An_{60}. Zonal development is only of a smaller degree. Among the porfiric constituents femic minerals are not present.

Among the microlites of the matrix augite and feldspar occur nearly in equal amount. The size of the magnetite grains does not exceed the 0,01 mm and in the unaltered fresh rock are uniformly distributed. The rock is sometimes penetrated by calcite veins cutting the feldspar too *(Fig. 2)*. In such cases, in some places of the feldspar, secondary calcite appears but not as a weathering product. The calciferous solutions affected only the already solidified rock along lithoclastic lines.

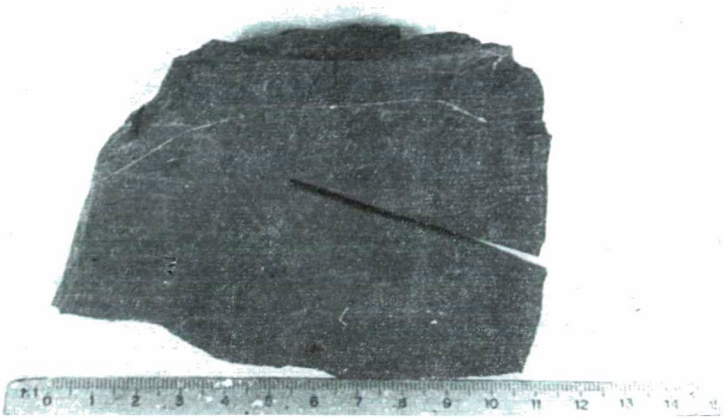

Fig. 1. Banded andesite

The rock may be considered also as an amafite.

The chemical composition of the fresh unaltered rock (the sample taken from the N-side of the lower strip pit of the mine of Pincepatak) is as follows:

TABLE 1

SiO_2	53,79 %
TiO_2	1,17
Al_2O_3	16,39
Fe_2O_3	4,53
FeO	4,47
MnO	0,25
MgO	3,06
CaO	7,46
Na_2O	2,72
K_2O	2,91
$+H_2O$	1,36
$-H_2O$	0,97
P_2O	0,21
CO_2	0,39
	99,68 %

Analysts: Mrs. I. SOHA and L. JANOVICS (1965, Hungarian State Geological Instute).

The CIPW normative minerals calculated from the chemical composition and the mineral composition reckonned according to SZÁDECZKY—KARDOSS's method [1966] are in fairly good agreement and taking into account the distribution of the microlites too, the computed mineral composition approaches the true one. The fact that the secondary minerals, except the calcite, are absent in the fresh rock, is naturally reflected also by the computed mineral composition.

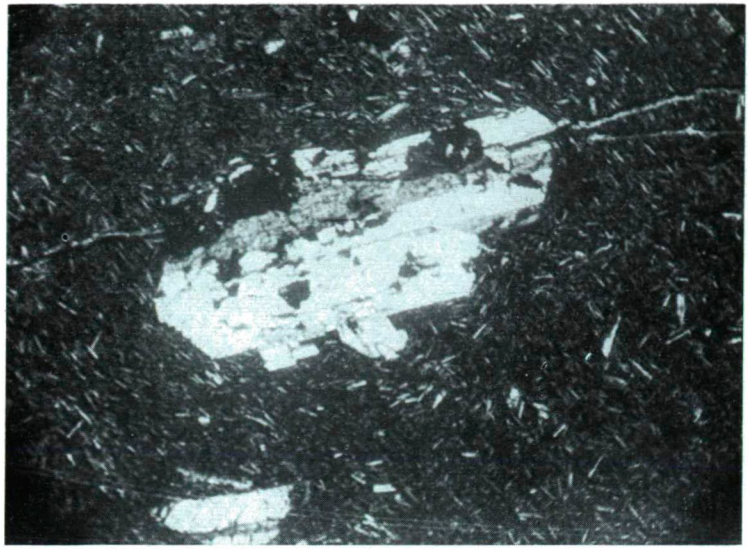

Fig. 2. Calcite veinlet cutting the matrix and the feldspar. Crossed nicols, ×30.

TABLE 2

Mineral	amount of the minerals in weight per cent according to the	
	CIPW method	SZÁDECZKY—KARDOSS's method
apatite	0,67	0,5
calcite	1,08	0,9
ilmenite	2,28	2,4
orthoclase	17,24	17,6
albite	23,06	22,2
anorthite	23,91	24,0
diopside	7,02	7,8
hypersthene	10,62	11,0
hematite	4,48	3,9
quartz	6,93	7,2
H_2O	1,36	1,4

The beginning of the weathering of the rock under epigene conditions appears firstly in the alteration of the matrix. The magnetite grains uniformly distributed in the fresh rock dissolve in some places, the matrix becomes mottled and owing to this fact, as these mottles contain no ore grains, the whole matrix becomes slightly light *(Fig. 3)*. The distribution of these mottles is mostly quite irregular, sometimes, however, in given direction a banded structure may be established, mostly in accordance with the original banding of the rock *(Fig. 4)*.

In the next step of the weathering the clay mineralization starts in these light mottles. As a result, minute hollows form, wherein, already in the early stage of the weathering, colloform material accumulates. In the colloidal material due to

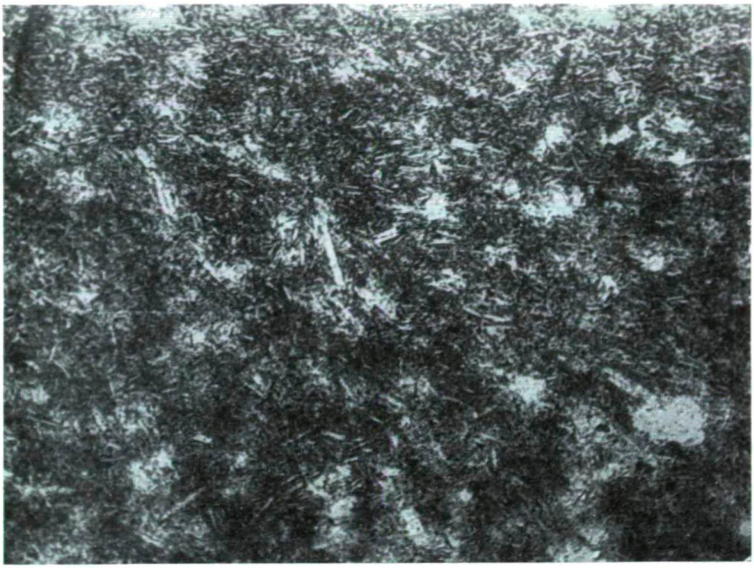

Fig. 3. Matrix becoming mottled at the early stage of the weathering. Crossed nicols, ×30.

loss of water irregular cracks can be observed as in *Fig. 5*. After a certain time the crystallization of the colloform material begins layer by layer and the material becomes ordered which can be especially well established between crossed nicols *(Fig. 6)*. The clay mineral on the wall of the hollows is of fine-fibrous appearance, the fibres in the single layers are perpendicular to the surface, in the inside of the

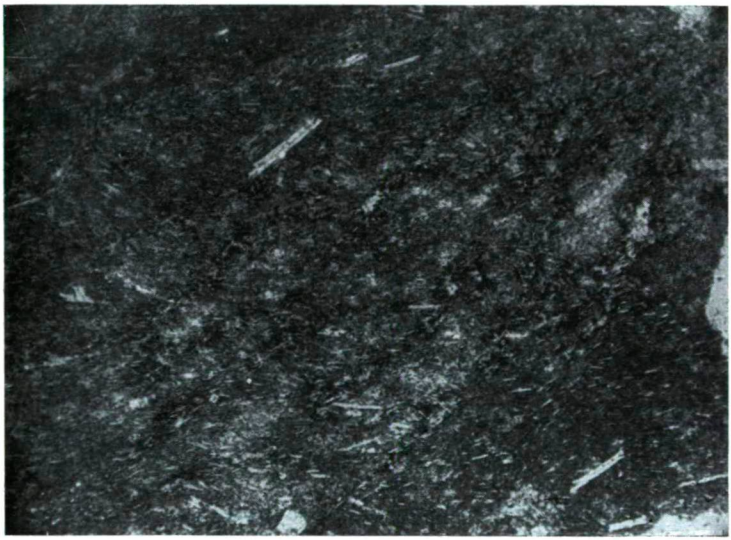

Fig. 4. Banded matrix at the beginning of weathering. Crossed nicols, ×30.

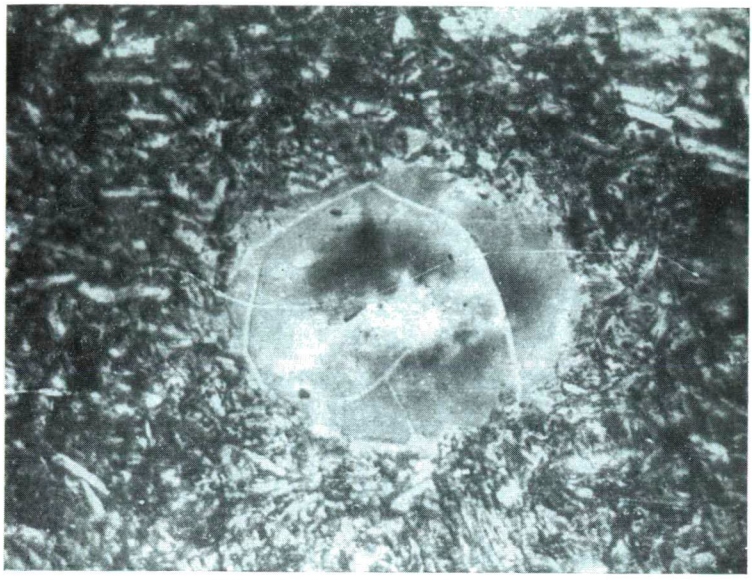

Fig. 5. Clay mineral as cavity filling. Plain light, ×100.

hollows, however, it is fine-grained. The clay mineral is light-yellow coloured with very weak pleochroism. The minute hollows are sometimes filled totally by this clay mineral, sometimes it appears only as a thin incrustation. The shape of these hollows varies greatly. Then and there they show spherical cross-section, sometimes are elliptical elongated *(Fig. 7)* and are always well contoured.

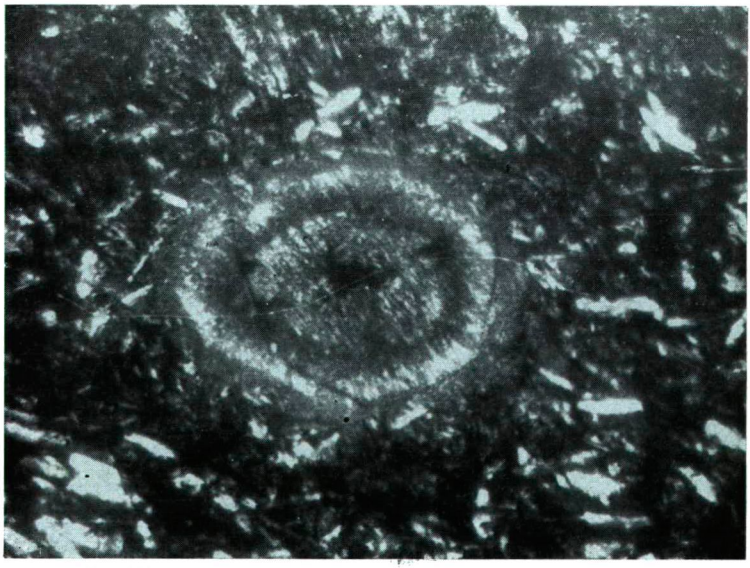

Fig. 6. Clay mineral as cavity-filling. Crossed nicols, ×100.

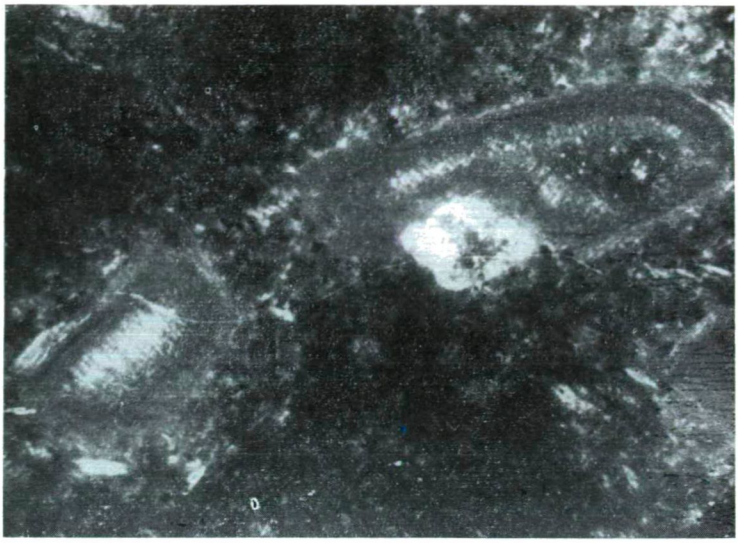

Fig. 7. Clay mineral filling of hollows of elliptical cross-section in the rock of banded matrix. Crossed nicols, ×100.

At an advanced stage of the weathering, the originally compact rock becomes porous, visible also to naked-eyes, and the walls of the — now already greater — irregular hollows are covered by gray, yellow, dust-like incrustation of clay minerals *(Fig. 8)*. These hollows are occasionally ordered in parallel rows following the original banded texture of the rock, mostly, however, arranged irregularly.

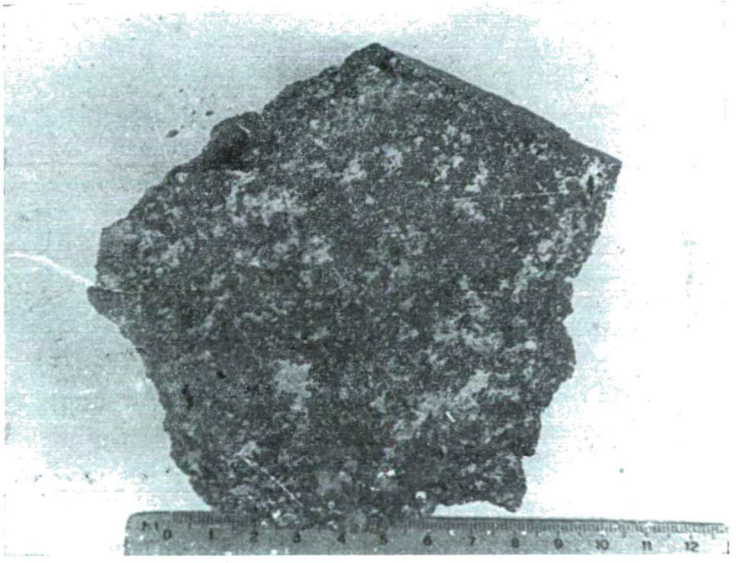

Fig. 8. Yellowish-gray clay mineral incrustation in the hollows of the rock becoming porous due to the weathering.

The clay mineral incrustation could be cautiously removed from the wall of the hollows. The X-ray study of different samples were performed, exposed in camera with 57,3 mm radius. The X-ray powder patterns are listed in *Table 3.*

TABLE 3

1		2		3		4		5		6	
d	I	d	I	d	I	d	I	d	I	d	I
4,527	s	4,550	s	4,504	s	4,550	diff	4,52	10	4,55	10
								4,18	2		
								3,82	2		
								3,37	2		
3,141	m	3,218	m	3,196	m	3,196	m			3,11	2
										2,96	2
2,569	s	2,591	s	2,555	s	2,541	w	2,61	5	2,62	8
								2,538	3	2,56	8
1,764	m							1,723	4	1,72	4
		1,694	m	1,682	m			1,675	5	1,67	4
1,520	s	1,518	s	1,513	s	1,511	w	1,519	10	1,52	10
								1,310	7	1,32	4
		1,295	w							1,30	4
										1,27	4
		1,259	w					1,258	6	1,25	4

1. Cu radiation without filter, 40 kV, 10 mA
2. Cu radiation with Ni filter, 40 kV, 10 mA
3. Cu radiation with Ni filter, 40 kV, 10 mA
4. Cu radiation with Ni filter, 40 kV, 10 mA, the sample treated with glycerine
5. Nontronite, Fe radiation without filter [MICHEJEV, 1957].
6. Nontronite, Fe radiation without filter [ASTM card, NAGELSCHMIDT, 1938]

s=strong, *m*= middle, w=weak lines.

Taking into consideration the literary data too, the clay mineral in question can not be considered as montmorillonite as in these patterns is lacking the strong line at 1,50 Å characteristic of the montmorillonite. The lines in the patterns point to beidellite and nontronite, respectively. The patterns are fairly poor in lines which fact can point rather to nontronite, although the line at 1,295 Å refers to beidellite. It seems possible that such a clay mineral is present, in whose octahedral layers no total exchange exist between Al^{3+} and Fe^{3+} ions and therefore it may be considered as a transition member between nontronite and beidellite, for the latter itself is also a transition member. In the pattern of the sample treated with glycerine the line at 4,55 Å became diffuse, the intensity and the number of the lines decreased.

The possibility of the formation of beidellite and nontronite under hydrothermal conditions is given according to NOLL's experiments [1936]., however, occurrences under epigene conditions are also known.

At the dissolution of the vitreous matrix the $Al(OH)_3$ and together with it a small $Fe(OH)_3$ separates and by these colloidal gels SiO_2 can be adsorbed. The formation of montmorillonite-type clay minerals requires no higher temperature and pressure, thus at the beginning of the crystallization the possibility of the formation of beidellite or nontronite is at hand.

This example shows that at the clay mineralization of fresh andesites under epigene conditions, clay mineral belonging to the montmorillonite-type may be formed owing to the effect of surficial descendent waters too. This may be one of the possibilities of its formation.

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LITHOLOGICAL AND GEOLOGICAL STUDY OF THE PLIOCENE FORMATIONS IN THE DANUBE-TISZA INTERSTREAM REGION
Part I

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INTRODUCTION

In the central and the southern parts now studied of the Danube—Tisza Interstream Region there are — as subsurface extensions of the Mecsek and the Villány Mts. — three zones of Palaeozoic, chiefly crystalline, and of Mesozoic, mainly sedimentary rocks which, deep-faulted in the east, trend from NE to SW in a rather high structural position *(Figure 1)*. Farther east, two subsidences have developed: the "*Kiskunság Basin*" in the central part of the Interstream Region, close to the Tisza, and the "*Szeged Basin*" in the south [CSIKY 1963, DANK 1963].

The thickness of the Late Tertiary and Quaternary basin filling is lesser above the zones of higher structural position, i. e. in the western part of the Danube—Tisza Interstream Region, but it becomes considerable farther east, in the area of the depression. In the latter, under Late Tertiary deposits, an accumulation of Cretaceous-Palaeogene flysch-like sediments is known [KÖRÖSSY 1962].

All this is well demonstrated *(Figure 2)* by the cross-section made across the Danube—Tisza Interstream Region by G. CSIKY [1963], which we completed with the most recent data. The continental deposits of the Helvetian as well as the marine sediments of the Tortonian and the Sarmatian are lacking in many places, the disconformity being further accentuated by postsedimentational erosion. In the initial stage of the Pliocene, the Early Pannonian, an over-all transgression took place, the sediments then deposited overlie unconformably the older rocks.

The Upper Pannonian deposits are also wide-spread throughout the Danube—Tisza Interstream Region. On the right bank of the Danube they are still exposed, but farther east they have subsided to great depths. Their thickness increases from W to E, just as it is the case with the Lower Pannonian [KERTAI 1957, KÖRÖSSY 1962, CSIKY 1963, DANK 1963].

After the Upper Pannonian brackish sedimentation, the last marine one in the Region, the Upper Pliocene (Levantine Substage) already witnessed a fluvio-lacustrine sedimentation of the Danube—Tisza Interstream Region. From the beginning of the Pleistocene, or somewhat later, but at least during much of the Pleistocene, an aeolian sedimentation was active in the central and the eastern parts of the Region. Corresponding to the climatic changes of the Pleistocene, during the glaciations some loess was deposited, while during the interglacials

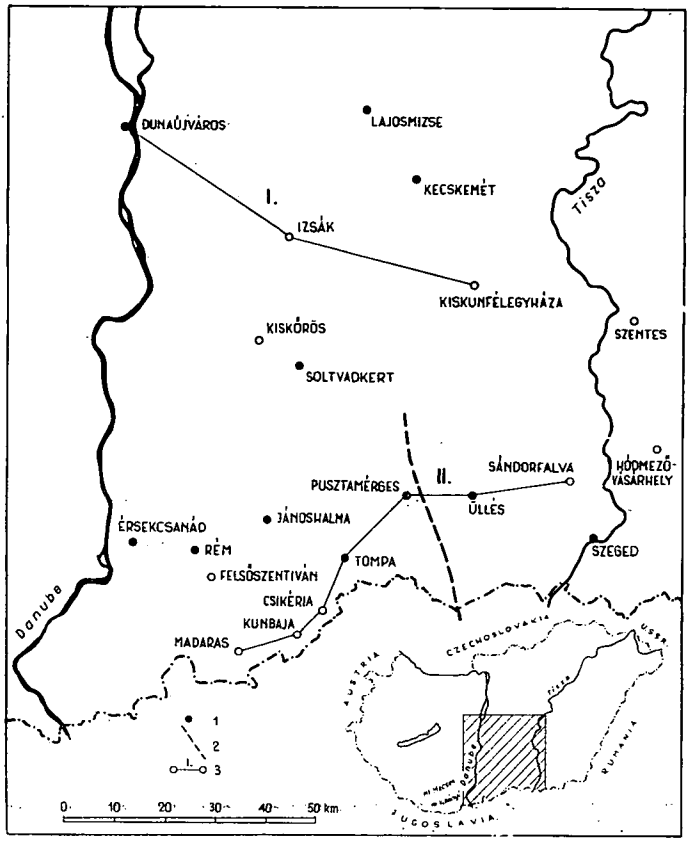

Fig. 1. Layout of the boreholes studied
1. The boreholes studied
2. Pusztamérges fault
3. Section line

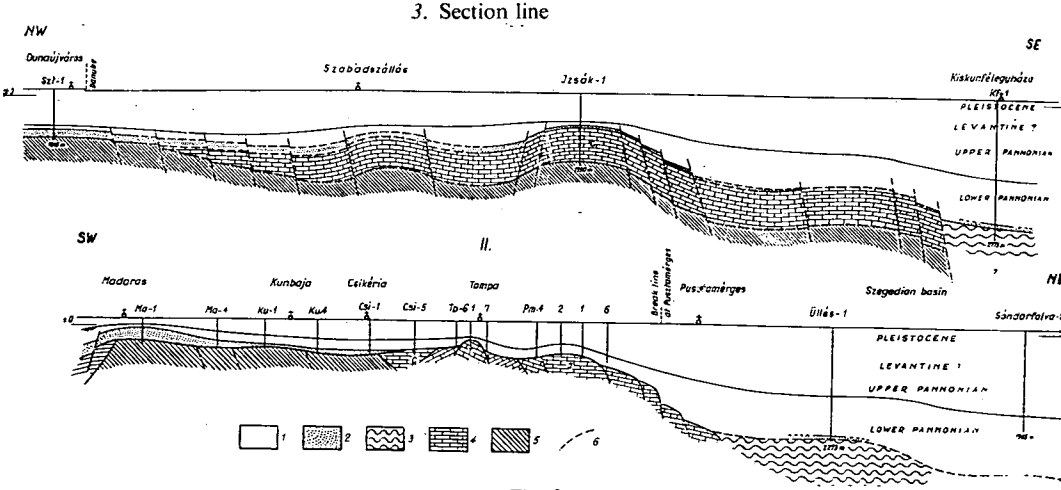

Fig. 2.

and interstadials the westerly winds blew aeolian sands out of the flood-plain of the Danube, which were laid down in the central part of the Danube—Tisza Interstream Region [MIHÁLTZ 1952, 1953, MOLNÁR 1961].

The recent drillings for water and hydrocarbon prospects have enabled us to study the lithology and geology of the Pliocene of the Danube—Tisza Interstream Region more fully than before. The investigations described in the paper have included several aspects thereof.

I. GRANULOMETRIC ANALYSES

The results of the granulometric analyses concerning the Danube—Tisza Interstream Region will be discussed in a chronological order, from W to E. The Pliocene formation in the Hungarian Basin can be divided in two parts — the Pannonian and the Levantine. The Pannonian is further split up into a lower and an upper stage of sedimentation [KÖRÖSSY 1962].

a) Granulometric composition of the Lower Pannonian sediments. The granulometric composition could be determined for a few samples only, owing to the diagenesis of the sediments. The results obtained for these samples are shown on sheet A of *Figure 3*, and in *Table 1*. A comparison by numbers of the granulometric curves and those given in the Table will permit to identify the drilling and the depth, from where the samples were taken. The sites of drillings are also shown in *Figure 1*. For those of the Lower Pannonian sediments, for which a carbonate content higher than 30 per cent was found, only the insoluble residue was analysed *(Table 1)*.

The few data available are insufficient for a comparison, but they do indicate that in the region of Kecskemét the Lower Pannonian sedimentation was more unsteady than in the structurally elevated part (area between Rém and Pusztamérges) of the Danube—Tisza Interstream Region.

b) Granulometric composition of the Upper Pannonian sediments. The investigations performed on samples from Kecskemét. Lajosmizse, and Soltvadkert lying farther north in the Danube—Tisza Interstream Region have shown that the sedimentation had undergone rapid changes *(Figure 3, B—C)*. A great number of samples with two concentration peaks were found *(Table 1, M_2)*, which is due to the alternation of thin layers because of the very frequent rhythmicity of sedimentation. For sampling the thin layers could not be separated, so that the curves reflect their averages. The oscillation of sedimentation was not of great amplitude, as there is hardly any difference in the grain size of the strata. In case of fine silt (0,005—0,02 mm ∅), along with the main peak the subsidiary one also falls within the size range of the fine silt, or possibly within that of clay (0,05 mm ∅). Major changes are marked by the appearance of sand layers.

Farther south from Soltvadkert the deposition of finer sediments can be observed *(Figure 3*, curves *23, 24, 25)*. This holds true even more markedly for the

Fig. 2. Geological sections across the Danube-Tisza Interstream Region (adopting data of G. CSIKY, 1963).
1. Pliocene and younger formations
2. Miocene formations
3. Upper Cretaceous-Palaeogene flysch-like sediments
4. Mesozoic formations (T=Triassic, J=Jurassic, C=Cretaceous).
5. Palaeozoic formations
6. Fault line.

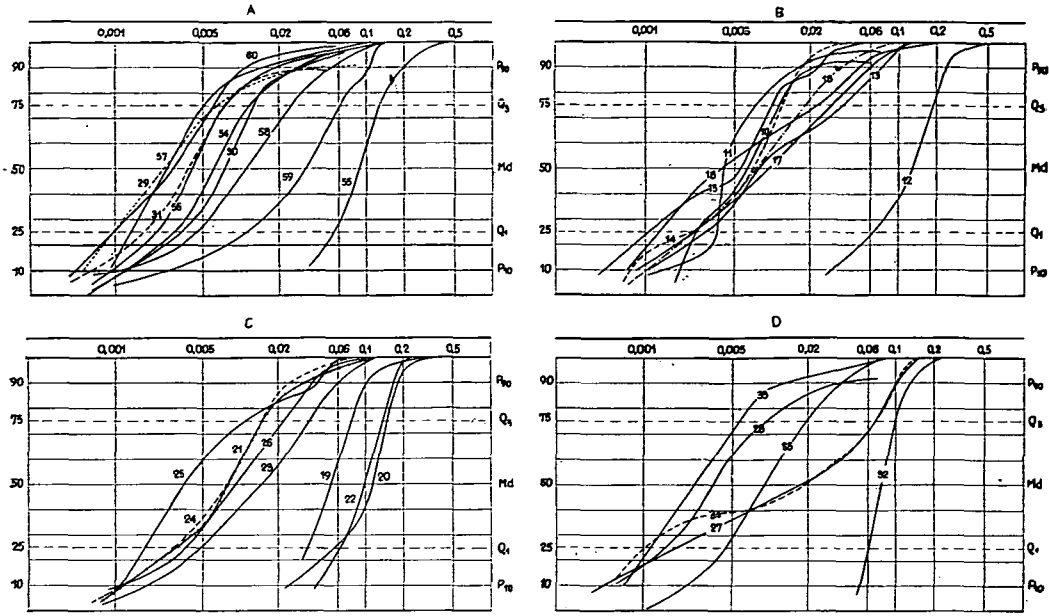

Fig. 3. Granulometric curves of Lower (A) and Upper (B, C, D) Pannonian sediments. (The numbers beside the curves permit identification with boreholes and depths shown in *Table 1*).

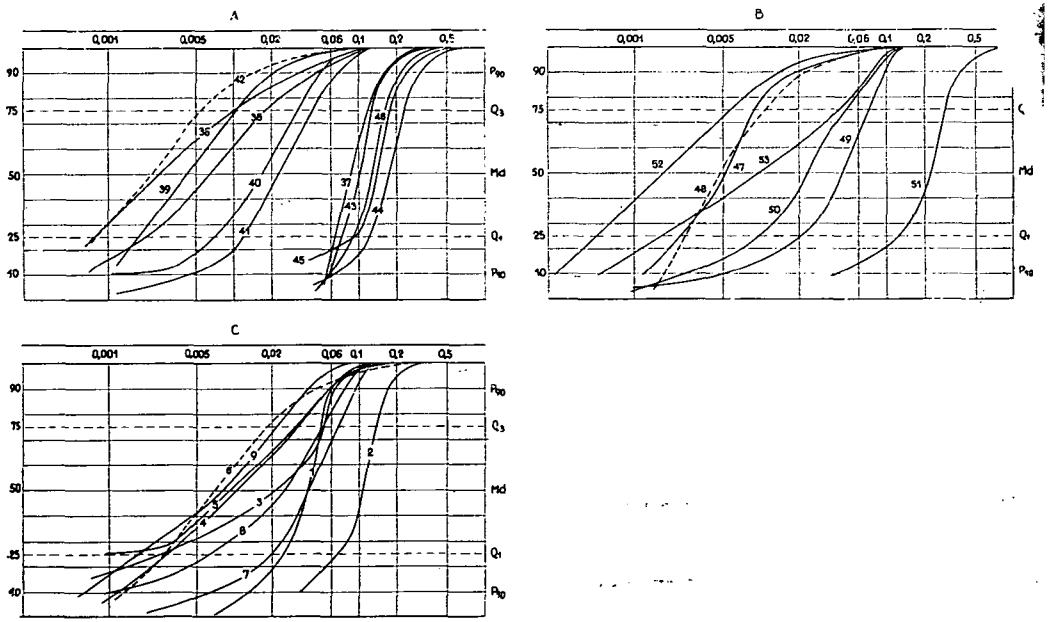

Fig. 4. Granulometric curves of the Upper Pannonian (A, B), Levantine and Pleistocene (C) sediments.

TABLE I

Numbert	Boring: Locality	Boring: Depth m	P_{10}	Q_1	Md	M_1	M_2	Q_3	P_{90}	*So* $So = \sqrt{\frac{Q_3}{Q_1}}$	*K* $K = \frac{Q_3 - Q_1}{2(P_{90} - P_{10})}$	*Sk* $Sk = \frac{Q_1 \cdot Q_3}{Md^2}$	$CaCO_3$ %	Type of Sediment	Age	
1.	Érsekcsanád—1	30—35	0,013	0,025	0,04	0,04	—	0,05	0,06	1,43	0,27	0,78	30,9	L.	Pleistocene	
2.	Rém—1	35—40	0,042	0,082	0,013	0,15	—	0,17	0,22	1,44	0,25	0,82	13,2	S. S.		
3.	Érsekcsanád—1	200—204,5	—	0,0024	0,022	0,023	—	0,054	0,066	4,74	—	0,42	2,2	C. Si.	PLIOCENE	Levantine
4.	Jánoshalma—7	200—204,5	0,0012	0,0031	0,011	0,013	—	0,033	0,055	3,25	0,28	0,60	17,7	F. Si.		
5.	Pusztamérges—2	148—153	—	0,0015	0,0095	0,012	—	0,031	0,062	4,53	—	0,52	19,9	F. Si.		
6.	Üllés—1	280—286/a	0,0013	0,0027	0,0067	0,0080	—	0,019	0,045	2,65	0,19	1,14	14,2	F. Si.		
7.	Üllés—1	350—356	0,0057	0,02	0,04	0,04	—	0,068	0,095	1,84	0,27	0,84	15,0	C. Si.		
8.	Üllés—1	718—723/a	0,00075	0,0062	0,025	0,022	—	0,052	0,077	2,89	0,30	0,52	20,8	C. Si.		
9.	Üllés—2	563—568	0,00062	0,0017	0,008	0,008	—	0,022	0,042	3,60	0,25	0,58	20,2	F. Si.		
10.	Dunaújváros—1	152—154	0,0019	0,0026	0,0065	0,0078	0,0022	0,012	0,023	2,15	0,20	1,03	31,0	F. Si.	EOPANNONIAN	Upper Pannonian
11.	Dunaújváros—1	251—253	0,0012	0,0038	0,0044	0,005	0,0020	0,0078	0,016	1,42	0,14	1,53	21,1	CL.		
12.	Dunaújváros—1	451—453	0,03	0,062	0,13	0,15	—	0,18	0,24	1,70	0,28	0,66	17,7	S. S.		
13.	Dunaújváros—1	551—553/a	0,0011	0,003	0,008	0,0065	0,0095	0,036	0,075	3,46	0,22	1'69	18,6	F. Si.		
14.	Dunaújváros—1	553—557	0,0008	0,0024	0,007	0,008	0,0009	0,012	0,027	2,23	0,18	0,59	33,2	F. Si.		
15.	Dunaújváros—1	603—605	0,00057	0,0011	0,0057	0,008	{0,0012 | 0,025}	0,01	0,023	3,02	0,20	0,34	26,6	F. Si.		
16.	Lajosmizse—3	505—510/b	0,00072	0,0013	0,0042	0,0019	0,024	0,043	0,047	5,75	0,45	0,32	26,6	CL.		
17.	Lajosmizse—3	700—705	0,00082	0,0023	0,0092	0,013	—	0,038	0,057	3,80	0,27	0,89	28,8	F. Si.		
18.	Lajosmizse—3	800,5—806	0,0011	0,0024	0,0075	0,0098	—	0,018	0,035	2,73	0,23	0,76	22,1	F. Si.		
19.	Kecskemét Ny—1	646—651/b	—	0,034	0,053	0,058	—	0,087	0,11	1,60	—	1,05	24,4	F. S.		
20.	Kecskemét Ny—1	760—765/a	0,026	0,057	0,11	0,13	—	0,15	0,19	1,62	0,28	0,71	19,9	S. S.		
21.	Kecskemét Ny—1	760—765/b	0,0012	0,003	0,008	0,0087	—	0,015	0,034	2,23	0,18	1,02	24,4	F. Si.		
22.	Kecskemét Ny—1	901—907	0,042	0,064	0,1	0,11	—	0,13	0,17	1,43	0,26	0,83	28,8	S. S.		
23.	Soltvadkert—1	557—562	0,0018	0,0048	0,015	0,014	—	0,035	0,062	2,70	0,25	0,74	29,8	F. Si.		
24.	Soltvadkert—1	646—651/a	0,0011	0,0029	0,008	0,008	0,047	0,015	0,027	2,27	0,23	0,69	24,4	F. Si.		
25.	Soltvadkert—1	912—917	0,0011	0,0018	0,0033	0,0042	—	0,015	0,042	2,97	0,16	0,25	28,8	CL.		
26.	Érsekcsanád—1	252—257	0,0011	0,0036	0,009	0,0012	—	0,022	0,039	2,47	0,24	0,98	26,6	F. Si.		
27.	Rém—2	201—206	0,0005	0,0018	0,0018	0,016	—	0,065	0,1	6,0	0,32	0,36	6,6	F. Si.		
28.	Rém—2	450—455	0,00055	0,0014	0,0035	0,0045	—	0,0087	0,027	2,50	0,13	1,33	26,6	CL.		
32.	Jánoshalma—2	300—304	0,053	0,062	0,08	0,082	—	0,1	0,13	1,27	0,25	0,97	19,9	F. S.		
33.	Jánoshalma—7	450—455	0,0007	0,0011	0,0025	0,0025	0,001	0,0056	0,13	2,25	0,16	0,99	28,8	CL.		
34.	Tompa—7	302—307,5	0,0005	0,001	0,019	0,055	—	0,077	0,095	2,76	0,40	0,41	26,6	C. Si.		
35.	Pusztamérges—2	200—205,5	0,0021	0,0044	0,009	0,011	—	0,19	0,038	2,08	0,20	1,03	22,1	F. Si.		
36.	Pusztamérges—2	250—255,5	—	0,00075	0,0025	0,0032	—	0,0098	0,033	3,60	—	1,11	4,4	CL.		
37.	Pusztamérges—5	450—455/a	0,055	0,062	0,090	0,11	—	0,14	0,17	1,50	0,34	1,08	4,4	S. S.		
38.	Üllés—1	760—766/a	0,00065	0,0019	0,0064	0,0072	—	0,018	0,048	3,07	0,17	0,83	27,5	F. Si.		
39.	Üllés—1	883—839/b	0,001	0,0018	0,0044	0,005	—	0,01	0,02	2,25	0,22	0,94	18,6	CL.		
40.	Üllés—1	1064—1070/b	0,0013	0,0065	0,017	0,02	—	0,032	0,048	2,25	0,27	0,75	18,7	F. Si.		
41.	Üllés—1	1217—1223	0,0044	0,011	0,023	0,024	—	0,044	0,069	2,0	0,26	0,92	23,0	C. Si.		
42.	Üllés—2	776—782/b	—	0,0008	0,0023	0,0025	—	0,0057	0,016	2,67	—	0,86	33,2	CL.		
43.	Üllés—2	1194—1200	0,057	0,074	0,1	0,11	—	0,13	0,17	1,32	0,25	0,96	19,9	S. S.		
44.	Üllés—7	1232—1237	0,063	0,12	0,18	0,19	—	0,23	0,32	1,39	0,21	0,85	15,5	S. S.		
45.	Üllés—7	1317—1323	—	0,09	0,14	0,16	—	0,18	0,24	1,43	—	0,82	15,5	S. S.		
46.	Üllés—8	1362—1367	0,058	0,09	0,13	0,14	—	0,16	0,22	1,33	0,22	0,85	9,7	S. S.		
47.	Szegedi Textil—m.	996—997,5/b	0,0011	0,0022	0,0052	0,0053	—	0,009	0,02	2,02	0,18	0,73	13,2	F. Si.		
48.	Szegedi Textil—m.	997,5—1000/a	0,0017	0,0025	0,0048	0,0052	—	0,011	0,023	2,10	0,20	1,0	11,1	F. Si.		
49.	Szegedi Textil—m.	997,5—1000/b	0,005	0,021	0,045	0,05	0,017	0,072	0,098	1,85	0,27	0,74	8,9	C. Si.		
50.	Szegedi Textil—m.	1500 m	0,0026	0,01	0,023	0,06	—	0,048	0,081	2,18	0,24	0,91	0,0	C. Si.		
51.	Szegedi Textil—m.	1600 m	0,04	0,12	0,22	0,24	—	0,29	0,38	1,55	0,25	0,72	8,9	M. S.		
52.	Szeged, Székelysor	1193—1194	0,00024	0,00052	0,0018	0,0024	—	0,0058	0,014	3,32	0,19	0,93	2,2	CL.		
53.	Szeged, Székelysor	1490—1494/a	0,00055	0,0016	0,0095	0,011	—	0,043	0,075	5,18	0,28	0,76	31,0	F. Si.		
54.	Kecskemét Ny—1	1169—1174	0,0013	0,003	0,0062	0,0062	—	0,012	0,028	2,0	0,17	0,94	22,1	F. Si.	PLIOCENE	Lower Pannonian
55.	Kecskemét Ny—1—	1182—1186/a	0,085	0,0055	0,090	0,1	—	0,13	0,2	1,57	0,30	0,88	33,2	F. S.		
29.	Rém—2	550—554	0,0005	0,0009	0,0024	0,0034	—	0,006	0,047	2,58	0,55	0,93	48,7	CL.		
30.	Rém—2	610—614,5	0,0012	0,0033	0,0074	0,0078	—	0,013	0,04	1,98	0,12	0,78	66,4	F. Si.		
31.	Rém—2	665—669	0,00065	0,0017	0,0038	0,004	—	0,0075	0,06	2,10	0,49	0,88	66,4	CL.		
56.	Rém—2	700,5—704,5	0,00095	0,0021	0,004	0,0042	—	0,0072	0,02	1,85	0,13	0,94	62,0	CL.		
57.	Jánoshalma—7	679—684	0,00095	0,0013	0,0025	0,0032	—	0,005	0,014	1,95	0,19	1,04	51,8	CL.		
58.	Tompa—7	449,5—455	0,0011	0,0045	0,011	0,012	—	0,025	0,054	2,35	0,19	0,92	11,1	F. Si.		
59.	Pusztamérges—2	526—531	0,0028	0,011	0,033	0,030	0,11	0,06	0,11	2,33	0,23	0,61	33,2	C. Si.		
60.	Pusztamérges—5	625—630	0,00047	0,001	0,0028	0,0055	—	0,006	0,011	2,45	0,23	0,76	18,9	CL.		

CL. = CLAY = 0,005 > mm ⌀, F. Si. = FINE SILT = 0,005—0,02 mm ⌀, C. Si. = COARSE SILT = 0,02—0,06 mm ⌀, L = LOESS = 0,02—0,05 mm ⌀, F. S. = FINE SAND = 0,06—0,1 mm ⌀, S. S. = SMALL SAND = 0,1—0,2 mm ⌀, M. S. = MEDIUM SAND = 0;2—0,05 mm ⌀

Upper Pannonian sediments of higher structural position between Érsekcsanád and Tompa in the south, where only clay, fine and coarse silts as well as fine sand occurred and no coarser sediment was encountered *(Figure 3, C—D,* curves *27—34).*

Pusztamérges represents a transition, between the high- and deep-structural areas. Predominantly fine-grained sediments were still found there, but they were already associated with small sands *(Figure 2,* curve *D 35, Figure 4,* curves *A 36—37).*

In the "Szeged Basin" at Üllés and Szeged all the sediment types ranging from clay to medium sand are available. By the way, medium sand was discerned there only *(Figure 4,* curves *A—B 38—53).* Along with the deeper structural position of the Pannonian sediments, this fact also shows changes in the conditions of sedimentation.

c) Granulometric composition of the Levantine sediments. The dating of the deposits under consideration is rater uncertain in many places. The sediments deposited in the time span between the marine basin filling of the Pannonian and the fluviatile one of the Pleistocene are classified as Levantine, adopting, here too, the stratigraphic scheme worked out by the National Oil and Gas Industry Trust (1950—1964). The samples analysed have yielded variable curves having no similarity one with another, as a contrast with those obtained for the Lower Pannonian and for a part of the Upper Pannonian. They are indicative of more unbalanced conditions of sedimentation fed by the rivers that entered the Levantine Lake *(Figure 4,* curves *C 3—9).*

d) Granulometric composition of the Pleistocene deposits — For comparison, some Pleistocene samples were also analysed. These have consisted of loess or small sand which are characteristic for their prominent sorting *(Figure 4,* curves *C 1—2).*

II. STATISTICAL EVALUATION OF THE GRANULOMETRIC ANALYSES

First of all the evaluation of the granulometric curves will be given. P_{10} is the grain size for 10 per cent, Q_1 for 25 per cent, *Md* for 50 per cent, Q_3 for 75 per cent, P_{90} for 90 per cent of the total material sampled. M_1 is a representative grain size understood as the grain diameter occurring most frequently in the sample. It lies in the centre of the curve, at its inflexion.

1. The value most commonly used in sedimentary petrological statistics is that of sorting which was calculated by using the formula of TRASK given in *Table 1.* If the sorting, the *So* values, were 1, the sediment would contain only grains of uniform size. Since this is not the case in Nature, so higher values are obtained.

According to TRASK, if *So* is lower than 2.5, the sediment is well-sorted; if it is about 3, the sediment has a normal sorting; and values higher than 4.5 would indicate a poorly sorted sediment. FÜCHTBAUER [1959] has further developed the method for the various types of sediments.

The *So* scales are indicated on the left side of the graphs. At the bottom the serial numbers from *Table 1* and from the granulometric curves are given. The numerals with an asterisk indicate curves with two concentration peaks (curve *5—8).*

a) So values of clay sediments from the Danube—Tisza Interstream Region. The Lower Pannonian clays have *So* values as low as the range between 1,85 and 2,85. They include accordingly few grain size classes. Clay is a

type of sediment in which the proper clay is associated with several other grain size classes present in varying amounts. The low values now obtained for the material sampled prove therefore that during the deposition of the Lower Pannonian sediments the southwestern part of the Danube—Tisza Interstream Region witnessed a low-rate, undisturbed, steady sedimentation *(Figure 5*, curves *29—60)*. (Only this area was sampled and tested.)

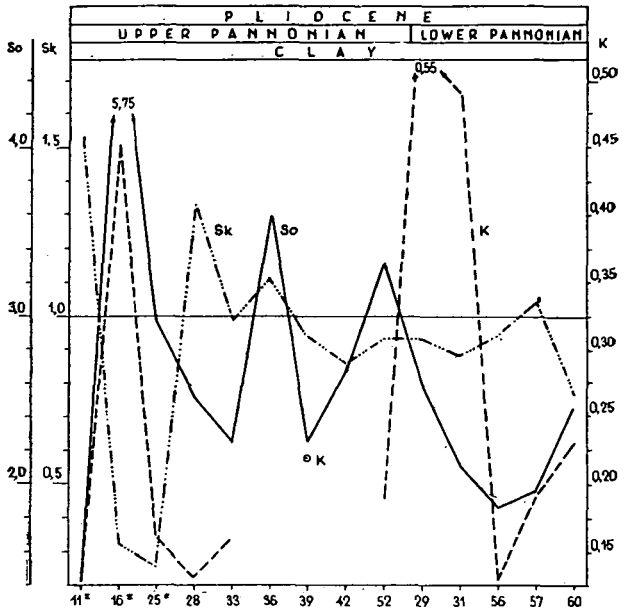

Fig. 5. Values of *So*, *Sk*, and *K* obtaine for the Lower-Upper Pannonian and Levantine sediments.

The sorting of the Upper Pannonian clays is characterized by its wider range of variation: 1,42—5,75 *(Figure 5*, curves *11—52)*. This oscillation of *So* values proves conditions of sedimentation more variable as compared with the Lower Pannonian. Changes of bathymetric conditions of the sea have taken place rapidly. No Levantine or Pleistocene clay was examined.

b) Most of the samples analysed were composed of fine silts.

The Lower Pannonian fine silts are characterized, like the Lower Pannonian clays, by a good sorting with *So* values ranging from 1,98 to 2,35. which testifies to the same fact as the low *So* values obtained for clay do *(Figure 6*, curves *30—58)*.

The *So* values, 2.1 and 6.0 alternatingly, obtained for the fine silts of the Upper Pannonian also suggest rapid changes in sedimentation *(Figure 6*, curves *10—53)*.

The *So* values of the fine silts of the Levantine also show a wide range of variation, from 2,65 to 4,55, i. e. an average value likewise higher, which proves less sorting and sedimentation of variable facies *(Figure 6*, curves *4—9)*.

c) The sorting of the Lower Pannonian coarse silts is good in spite of the double peaks obtained *(Figure 7,* curve *59).*

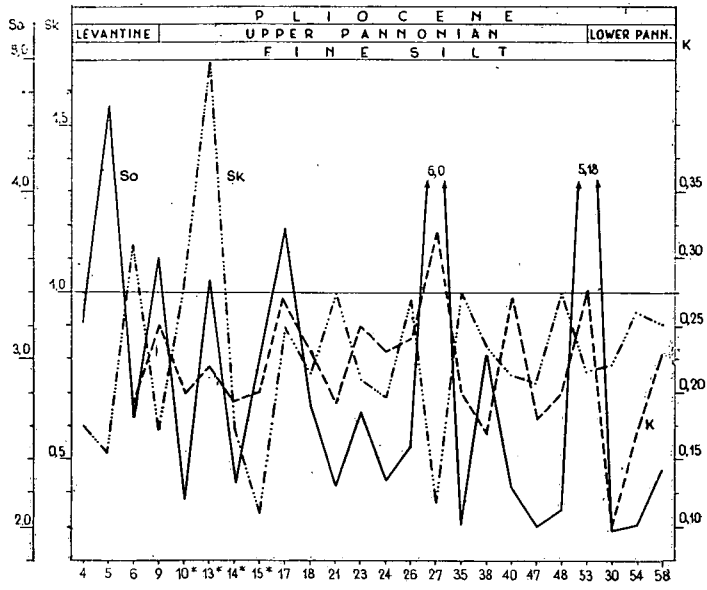

Fig. 6. Values of *So, Sk* and *K* obtained for the Lower and Upper Pannonian and Levantine fine silt sediments.

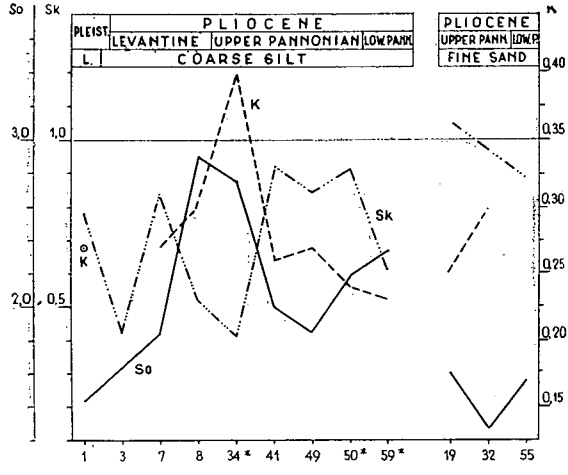

Fig. 7. Values of *So, Sk,* and *K* of different aged coarse silt and fine sand.

The Upper Pannonian coarse silts yield varying *So* values, like the other synchronous sediments do. The coarse silts of the Levantine are characterized by the same values *(Figure 7,* curves *3—50).*

d) The *So* values obtained for the few samples of Lower and Upper Pannonian fine sand vary between 1,27 and 1,6, a proof of a very well-sorted sediment *(Figure 7,* curves *19—55).*

e) The *So* values of the Upper Pannonian and the Pleistocene small sands vary from 1,32 to 1,70, they are thus very low. For the medium sand of the Upper Pannonian a value of 1,55 was obtained, which also indicates a well-sorted sediment *(Figure 8,* curves *2—51).*

2. Kurtosis is an expression for the sharpness of peaks of the granulometric curve. It gives the comparison of the central extension of the granulometric curve to its total extension, i. e. the ratio of the curve part of the non-quartile grain com-

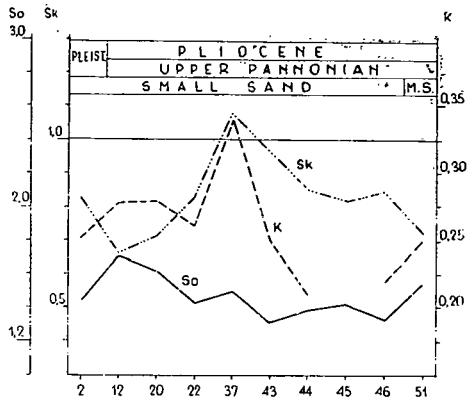

Fig. 8. Values of *So*, *Sk*, and *K* obtained for the small sands of the Upper Pannonian and the Levantine and for the medium sands of the Upper Pannonian.

position is compared to that of the quartile one. Its value is calculated by using the formula form *Table 1.* If the value of *K* is higher, the curve part of the non-quartile grain composition will be steeper (shorter), — if the value of K is lower, it will be more flattened (longer).

The *K* values of the clays from the Danube—Tisza Interstream Region are characterized by their wide range of variation: 0,13—0,55 *(Figure 5,* a scale of *K* values is given on the right side of the graph). The lacking *K* values could not be calculated, as during analysis the curve did not attain 10 per cent (P_{10}).

The *K* values obtained for the fine silts of the Lower Pannonian are still rather variable, those obtained for the Upper Pannonian, 0,17—0,32, being already more steady. Irrespective of the latter prominent figure, they vary within a range as narrow as 0,17—0,27 *(Figure 6).*

The coarse silts and sands have yielded *K* values which are still rather high *(Figures 7—8).*

It can thus be stated that the Pliocene sediments from the Danube—Tisza Interstream Region yield rather variable K values, involving in some cases a smaller, in others a greater non-quartile fraction, i. e. they reflect unsteady conditions of sedimentation.

3. Skewness (*Sk*) may diverge from the medium size range either towards the finer grain fraction, or towards the coarser one *(Figures 3—4).* If *Sk* equals 1, we have to do with a curve diverging towards the coarser grain fraction; and if

TABLE 2

Number	Boring		Dominantly Magmatic Minerals										Dominantly Metamorphic Minerals												Other Minerals				Weathered Minerale	Total Quantity of the Heavy—Minerals in the Examined Fraction	Diameter of Examined Fraction in MM	Dominant Grain Diameter MM
	Locality	Depth m	Hypersthene	Other Rhombic Piroxenes	Augite	Diopside	Basaltic Hornblende	Magnetite	Biotite	Apatite	Titanite	Zircon	Chlorite	Tourmaline	Epidote	Zoizite	Rutile	Hornblende	Actinolite—Tremolite	Anthophyllite	Garnet	Staurolite	Andalusite	Cyanite	Glaukophane	Calcite-dolomite	Pyrite	Limonite	Other Micas				
1.	Dunaújváros—1	103—105	0,7	3,5	1,4	6,2	—	0,7	—	0,7	—	—	24,3	1,4	2,8	—	0,7	—	—	—	2,1	—	—	0,7	—	0,7	0,7	4,1	6,2	42,4	0,8	0,1—0,2	0,06—0,1
2.	Dunaújváros—1	451—453	—	3,4	1,4	2,1	—	0,7	—	4,7	—	—	16,2	1,4	0,7	—	—	—	—	—	29,8	2,1	—	0,7	—	8,2	—	2,1	0,7	25,8	1,1	0,1—0,2	0,1—0,2
3.	Dunaújváros—1	500—502	0,8	0,8	0,8	—	—	0,8	—	2,3	—	—	66,5	0,3	—	—	—	—	—	—	2,3	—	—	—	0,8	5,4	0,8	4,7	4,7	8,5	0,5	0,1—0,2	0,1—0,2
4.	Dunaújváros—1	651—653	—	—	—	—	—	—	—	—	—	—	54,2	—	—	—	—	—	—	—	—	—	—	—	—	20,8	—	2,1	4,1	18,8	2,6	0,1—0,2	0,06—0,1
5.	Dunaújváros—1	800—803	—	—	—	—	—	1,1	88,6	—	—	2,0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1,1	—	7,2	0,07	0,1—0,2	2,0—10,0
6.	Kecskemét Ny—1	213—215	1,2	2,4	10,4	3,0	3,6	4,8	—	—	—	—	6,8	0,6	1,8	—	—	4,8	1,2	1,2	16,4	1,8	0,6	1,2	—	0,6	0,6	3,6	—	33,4	5,0	0,1—0,125	0,06—0,1
7.	Kecskemét Ny—1	646—651	—	—	—	—	—	2,4	—	—	—	—	59,6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1,6	17,4	19,0	5,3	0,1—0,125	0,06—0,1
8.	Kecskemét Ny—1	760—765	—	2,5	1,9	8,1	0,6	1,9	—	3,7	0,6	—	24,6	1,9	1,2	1,2	0,6	—	—	—	15,0	0,6	0,6	1,9	—	6,9	—	3,1	3,7	19,4	2,8	0,1—0,125	0,1—0,2
9.	Kecskemét Ny—1	901—907	—	—	0,7	—	—	2,0	—	8,0	—	—	57,7	2,0	—	0,7	—	—	—	0,7	13,5	—	—	0,7	—	4,0	—	2,0	4,0	4,0	1,2	0,1—0,125	0,1—0,2
10.	Kecskemét Ny—1	1182—1186	0,5	—	—	1,5	0,5	2,5	—	7,1	—	0,5	47,9	1,0	3,1	—	—	—	—	—	19,7	1,0	—	—	—	4,0	—	2,0	1,5	7,2	1,4	0,1—0,125	0,06—0,1
11.	Kecskemét Ny—1	1567—1571	—	—	—	—	—	—	—	—	—	—	31,2	—	—	—	—	—	—	—	—	—	—	1,6	—	—	0,9	—	4,9	61,5	1,7	0,1—0,2	0,06—0,1
12.	Jánoshalma—7	300—304	—	0,7	1,3	1,3	—	—	—	1,3	—	—	56,4	—	1,3	—	—	0,7	1,3	—	2,0	0,7	—	0,7	—	2,7	8,8	4,1	9,3	7,4	0,8	0,1—0,125	0,06—0,1
13.	Tompa—7	197—202,2	—	2,6	3,1	3,6	—	2,1	—	5,7	—	—	29,0	1,6	5,2	—	—	9,8	5,7	—	5,2	1,0	—	0,5	—	1,6	—	0,5	1,0	21,8	0,9	0,1—0,2	0,06—0,1
14.	Pusztamérges—5	450—455	—	—	0,7	—	—	—	—	0,7	—	—	79,3	—	2,2	—	—	0,7	0,7	—	—	—	—	—	—	—	—	0,7	3,6	11,4	0,7	0,1—0,2	0,06—0,1

it is lower than 1, with one diverging towards the finer fraction (values of *Sk* in *Table 1)*. The skewness of the Lower Pannonian clays is low, that of the Upper Pannonian ones being variable in the N of the Danube—Tisza Interstream Region, but steady elsewhere. *(Figure 5,* scale of *Sk* values on the left side of the diagram). The unsteadiness of *Sk* values fiurnishes a further evidence of rapid changes in the conditions of sedimentation.

The skewness obtained for fine silts is prominent in the more northerly part of the Danube—Tisza Interstream Region, but is more steady elsewhere, just as was the case with clays,

The curves of coarse silts show skewness merely towards finer grain sizes *(Figure 7)*. The curves of fine sands are nearly symmetric, while the small sands, all but sample Nr. 37, diverge towards the finer grain size fraction *(Figure 8)*.

III. INVESTIGATION OF HEAVY MINERALS

Information on the composition of heavy minerals in the Late Tertiary and Quaternary deposits of the Hungarian Basin has been furnished in several papers (see *Figure 9* showing the boreholes worked up) [SZABÓ 1955, MOLNÁR 1961, 1962, 1964, 1965].

Having completed the earlier data with the most recent results obtained for the heavy mineral composition of sediments from the Danube—Tisza Interstream Region, we were able to point out the main directions of transport during the Pliocene and the Pleistocene within the Hungarian Basin *(Table 2, Figure 9)*. During the Pannonian, sediments rich in chlorite were introduced from the West into the area of the Danube—Tisza Interstream Region. Such a composition is exhibited by samples Dunaújváros 1—4, Kecskemét 7—11 as well as the samples from Jánoshalma, Tompa, Pusztamérges (see *Table 2*).

At the same time, in the southern part of the Trans-Tisza Region sediments deriving from the E were deposited. Their actual direction of transport is not yet known, that is why it has not been plotted. The composition of these sediments is characterized, along with chlorite, by a varied assemblage of metamorphic heavy minerals. The sediments deriving from two different directions wedge out along the line of the Tisza, near Szentes, Sándorfalva, and Szeged. This phenomenon culd be made well evident by drilling in the afore-mentioned places. The sediments deposited at Pusztaszöllös, Csanádapáca were removed from NE, in part from the crystalline area that had remained in a higher structural setting in the Trans-Tisza Region. They are also characteristic for the abundance of chlorite *(Figure 9,* curve *2)*.

The Levantine and Pleistocene deposits of the Danube—Tisza Interstream Region were transported from NW, from a source area with a geological setting similar to that of the area drained by the Danube at present. (In the Pleistocene the westerly winds blew sands out of the bed of the Danube and laid them down in form of aeolian sands farther east.) They show nearly the same composition as the Danube alluvium does. An example of this composition is sample 6 *(Figure 9,* curve *3)*.

In the same period, sediments of varied compositions consisting predominantly of igneous minerals were deposited in the Trans-Tisza Region. They were introduced partly by pre-existing palaeostreams, partly by the present rivers *(Figure 9,* curves *4—7)*. An additional characteristic feature of these sediments in the S of the Trans-Tisza Region is the fact that the abundance of the metamorphic minerals

tends to decline upwards. Throughout the Trans-Tisza Region, particularly three minerals have a diagnostic value. These are hypersthene and augite in the northern Trans-Tisza Region and hypersthene, augite, and basaltic amphibole in the southern Trans-Tisza Region.

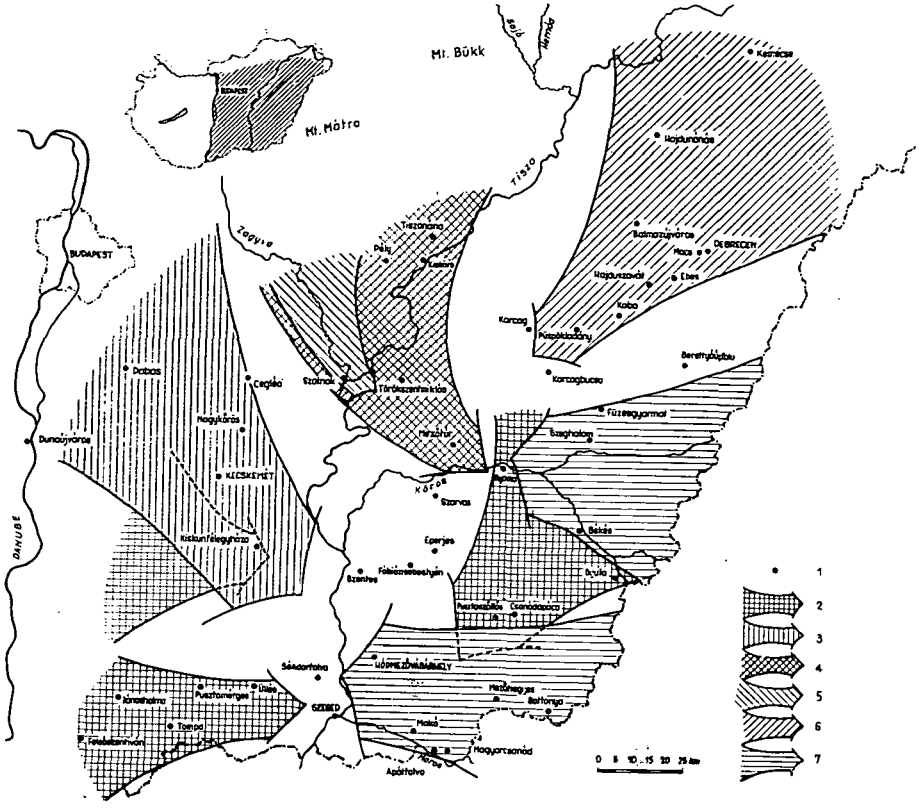

Fig. 9. Directions of transport during the Pliocene and the Pleistocene in the Hungarian Basin.
1. Sites of the boreholes studied
2. Directions of transport during the Pannonian in the Danube-Tisza Interstream Region and the Trans-Tisza Region.
3. Direction of transport by the Danube.
4. Direction of transport by the palaeo—Zagyva—Sajó
5. Direction of transport by the Zagyva
6. Direction of transport by the Maros—Kőrös.

CONCLUSIONS

1. The granulometric composition of the Lower Pannonian sediments is indicative of rapid changes in sedimentation in the northern part of the Danube—Tisza Interstream Region, and of a low rate, more quiet sedimentation in the SW.

The granulometry of the Upper Pannonian formation suggests an unsteady sedimentation in the N, the region of Dunaújváros and Kecskemét and the "Szeged Basin", and a less disturbed sedimentation in the SW, between Érsekcsanád and Tompa.

The Levantine formation exhibits a granulometry of varying facies, the Pleistocene deposits show an aeolian sedimentation.

2. The sorting of the Lower Pannonian clays and fine silts is rather high, that of the Upper Pannonian and Levantine clays, fine silts and coarse silts shows more or less fluctuation which proves that in the Upper Pannonian and the Levantine the sedimentation must have been more disturbed, more unsteady (changes in the bathymetric conditions of the sea). The changes were not too great, since the intercalated sands are well-sorted.

3. The kurtosis of the Lower Pannonian sediments is rather variable, that of the Upper Pannonian and Levantine ones being more balanced, which holds particularly true for the fine and coarse silts and the fine sands.

4. The skewness of the Lower Pannonian clays is low, that of the Upper Pannonian clays recording more changes in the northern part of the Danube—Tisza Interstream Region. The skewness obtained for the Lower and the Upper Pannonian fine silts is less pronounced, especially so in the southern part of the Danube—Tisza Interstream Region. The fine silts of the Levantine show an unsteady skewness, the coarse silts and the sands are skewed but towards the finer grain fraction.

5. The analysis of the samples for heavy minerals has confirmed former suggestions as to the derivation of the Pannonian deposits of the western Danube—Tisza Interstream Region from a western source area. The heavy minerals contained in the Levantine and Pleistocene sediments suggest source area corresponding with or nearly similar to that drained by the Danube.

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ON THE RELATIONSHIPS BETWEEN LATTICE STRUCTURE AND „ZEOLITE WATER" IN GMELINITE, HEULANDITE AND SCOLECITE

by

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Research into relationships between the lattice and the "zeolite water" content of some zeolites [PÉCSI—DONÁTH, 1965, in print] has suggested that "zeolite water" might occur in various types of bond. This could indeed be proved for e. g. natrolite and desmite, whereas the water content of chabasite turned out to consist in the main of typical "zeolite water". In therefore seemed indicated to carry out a manysided, detailed study of zeolite minerals of the same lattice type as the above-named, in order to enquire into the nature of the bond in which their water content occurs and into the relationship of that bond to the lattice. The substances studied were:

Gmelinite		Nova Scotia	Canada
Heulandite		Fassa Valley	Switzerland
Scolecite		Attlitz Valley	Switzerland
	and	Boulands Tundra	Iceland

Investigation started with the recording of the derivatograms of these zeolites, and with the study of the DTA graphs forming part of those derivatograms. Parts of the samples were heated for some time at the peak temperatures indicated by the DTA graphs. Both the original substance and the heated samples were subsequently submitted to X-ray diffractometry and infra-red spectroscopy. The above examinations were completed by full chemical analyses and regeneration tests.

Gmelinite is closely related to chabasite both structurally and chemically. Its silicate lattice has, according to H. STRUNZ [1956]. L. S. DENT and J. V. SMITH [1958], R. M. BARRER [1944], BARRER and KERR [1959], the following structure: There is a cage parallel to the *c* axis, consisting of rings of 12 SiO_4 tetrahedra. This cage have on both ends hexagonal double rings of six SiO_4 tetrahedra each, the cavities of which are likewise parallel to the *c* axis, and narrower than the foregoing ones: indeed, the minimum diameter of the cage is about 6,4 Å that of the hexagonal ring, about 3,4 Å. In principle, the cage should be more adsorptive, but most of the water actually absorbed in the rings, because, according to R. M. BARRER [1944], most of the Na ions occupy the cation positions of the larger cavities.

The dehydration process of gmelinite may be traced on the DTA and DTG graphs *(Fig. 1)*. There are two sizable endothermic peaks at 240 and 340 degrees centigrade, respectively, and a weak one at 380 degrees.

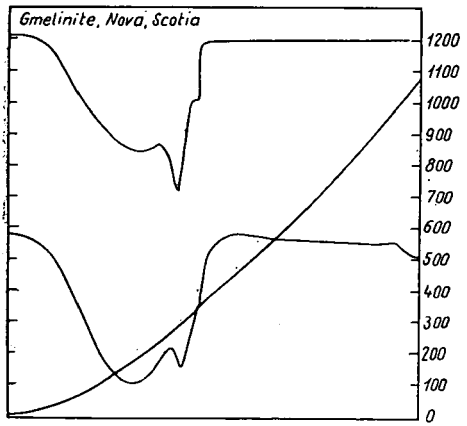


Fig. 1. Gmelinite, Nova Scotia, Canada. DTA and DTG graphs.

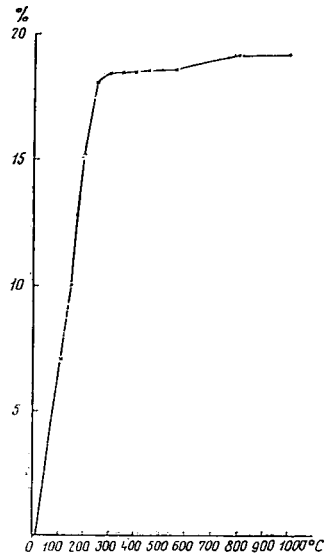


Fig. 2. Dehydration graph of gmelinite

The weight loss during the heating indicates that 18,40 per cent of the total water content of 19,20 per cent escapes up to 300 degrees centigrade, a few further tenths of one per cent leave up to 400 degrees; the rest escapes slowly, gradually up to 1000 degrees *(Fig. 2)*.

The first peak indicates the escape of most of the water content, the second one the escape of a few tenths of a per cent of water and some change in the lattice. This is presumably the cause also of the small endothermic peak at 380 degrees, which also entails some weight loss (see DTG graphs).

Weight loss in a current ot air, as established by the devolatilization method of SZÁDECZKY—KARDOSS E.—SIMÓ, B. [1962], is given in the *Table 1.*

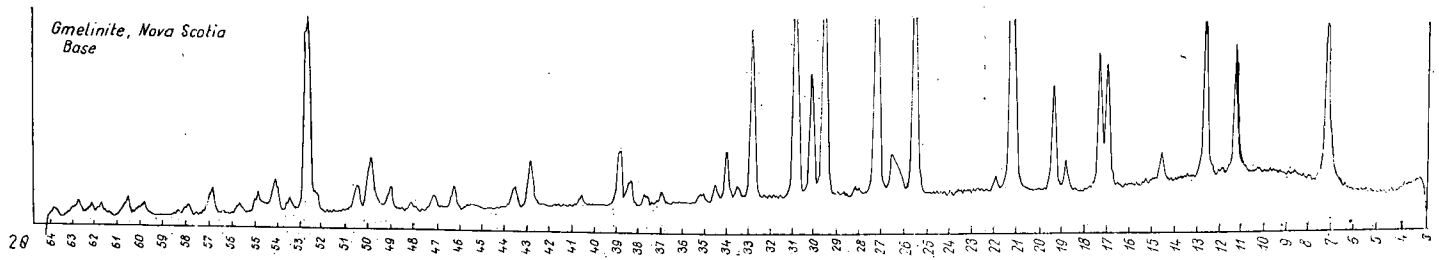
TABLE 1

Weight loss as determined by devolatilization in per cent, for two hours

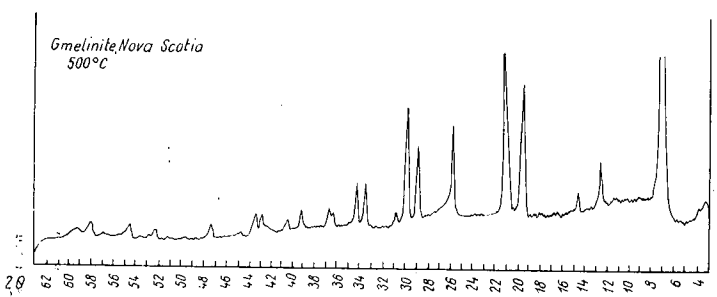
Temperature degrees C	Gmelinite, Nova Scotia, Canada
280	18,22 %
280 to 340	0,42
340 to 370	0,09
370 to 430	0,05

Escape of water proceeds in essentially the same manner, except that the air current withdraws the majority of water (18,3 per cent) below 280 degrees.

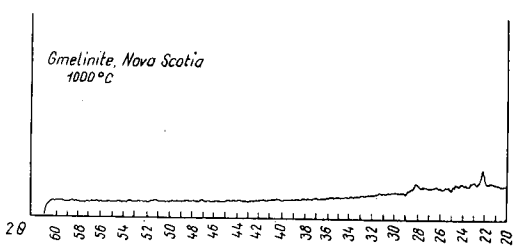
Fig. 3. X-ray diffractometry patterns of gmelinite



a) unheated



b) heated at 500° C



c) heated at 1000° C

X-ray diffractometry (Fig. 3/a) has been applied to trace the structural modifications taking place under heating. The lines of gmelinite were present on all heated samples, with at most some decrease in intensity. Above 350 degrees centigrade, some amorphous substance is also formed and a slight shift of the d/hkl values suggests a certain measure of lattice deformation *(Fig. 3/b)*.

Oligoclase and quartz could be identified in the sample of gmelinite heated at 1000 degrees *(Fig. 3/c)*. There was however, quartz also in the original sample; as the lines of quartz were weaker in the heated sample, quartz cannot be declared with certainty a product of transformation.

Infra-red spectroscopy has been performed on both the original sample and on the heated samples subjected to X-ray diffractometry *(Fig. 4)*. Peaks occuring between 3460 and 3700 cm^{-1} in the one hand and between 3000 and 3460 cm^{-1}

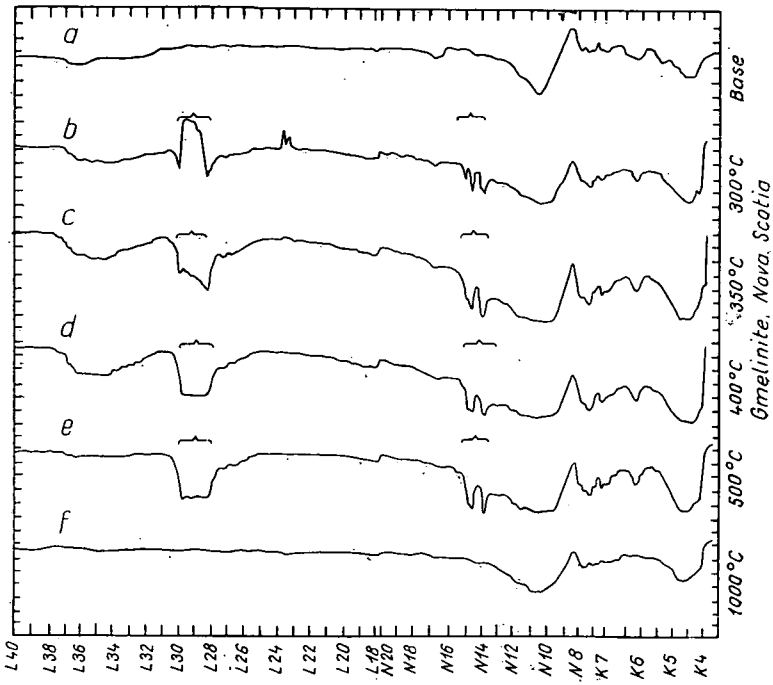


Fig. 4. Infra-red spectrograms of gmelinite
a) unheated
b) heated at 300 C
c) heated at 350° C
d) heated at 400° C
e) heated at 500° C
f) heated at 1000° C

on the other indicate two types of water. The absorption band between 1620 and 1720 cm^{-1} is typical of the OH^- radical, that between 400 and 1200 cm^{-1} of the silicate lattice.

In this latter band, the OH—Al bond could be detected at 920 cm^{-1} and the Si—O—Al bond at 750 cm^{-1}. All the above-said substantially holds also for the

samples heated at 300, 350, 400 and 500 degrees, respectively, with the modification that in the latter the absorption band at 550 cm^{-1} typical of the Si—O—Al [VI] bond is also present. The sample heated at 1000 degrees contained no water at all and its silicate lattice could be identified with that of feldspar.

Its *chemical composition* is given by the *Table 2.*

TABLE 2

Anal.: dr. Simó B.
Gmelinit, Nova Scotia, Canada

SiO_2	59,44 %
TiO_2	0,00
Al_2O_3	17,21
Total iron	0,43
MnO	0,00
MgO	0,02
CaO	0,92
Na_2O	6,45
K_2O	0,40
Total water	16,04
P_2O_5	0,00
CO_2	0,00
	100,91 %

This chemical composition results in the following structural formula:

$$Na_{1,342}\ K_{0,055}\ Ca_{0,104}\ Al_{2,179}\ Fe_{0,005}\ Si_{3,959}\ O_{12}$$

(The quartz content furnished by X-ray diffractometry has been subtracted from the SiO_2 data.)

Taking into account also the water content, we get

$$Na_{1,361}\ K_{0,055}\ Ca_{0,105}\ Al_{2,211}\ Fe_{0,005}\ Si_{4,016}\ O_{12} \cdot 5,827\ H_2O.$$

Studies into *the regeneration* of gmelinite have shown that upon heating at 100 degrees centigrade and exposition to an atmosphere saturated with water vapour the mineral resorbs its full original water content, and even about 1 percent more than that. Heating at 150 and 200 degrees yields the same result. This is remarkable in as much as water loss increases with temperature:

a maximum of 7 percent at 100 degrees centigrade

10 150
15 200

whereas water content after saturation in vapour always attains the maximum, about 18,50 percent. That is, regeneration tends to improve with increasing temperature. However, resorption after heating at 250 and 350 degrees does not exceed an average 9 to 10 percent *(Fig. 5).*

These *results* largely support the resemblance between gmelinite and chabasite, while pointing out also some differences in their properties.

Besides the similarity of the lattices, it is the similarity of the process of regeneration that should be emphasized in the first place. The infra-red absorption bands

of the silicate lattice, occurring in the 400 to 1000 cm^{-1} range, also resemble those of chabasite and confirm the above statement. Gmelinite, like chabasite, loses most of its water content below 200 degrees centigrade and only a small part (less than chabasite) above.

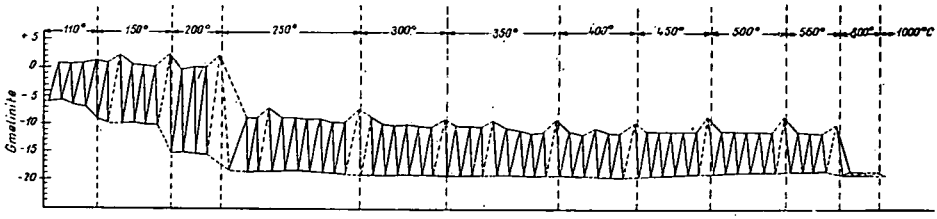


Fig. 5. Regeneration graph of gmelinite

The DTA graph of gmelinite, however, is widely different from that of chabasite. Also, the absorption band of water in the 3000 to 3700 cm^{-1} range of the infrared spectrum is different. Comparison of the dehydration and devolatilization processes also suggests that the difference resides in the nature of the water bond. In the author's opinion the majority of the water content is typical "zeolite water" also in gmelinite the rest being water bound to the cation. This latter, however, seems to be bound much stronger than in chabasite [PÉCSI-DONÁTH É., 1965] and its removal takes more energy, as witness the sharp endothermic peak of the DTA graph. As stated above, structural research has pointed out the presence of two kinds of cavities in the lattice, and water may be present in both the wider and the narrower cavities. It seems likely that lack of space beside Na and other cations substituting it in the wider cage as suggested by R. M. BARRER [1944] forbids the entry of any considerable amount of water, and any water entering into those cavities is immediately bound to the cations. Most of the water content occupies the small cavities in a weaker type of bond. This type water escapes gradually up to 300 degrees centigrade, whereas the type bound to the cations leaves under the formation of a sharp endothermic peak and a certain change in lattice dimensions. Complete collapse of the lattice takes place at 800 degrees, whereas a new phase (feldspar) is not formed until 1000 degrees.

From a practical standpoint, gmelinite heated to any temperature below 800 degrees performs as a fairly high-grade adsorbent and regenerates almost completely. Best adsorption is attained by heating at 250 degrees. This is presumably the optimum temperature for dislocating the lattice to such a degree as permits the substitution of almost all the escaping water by the substance to be adsorbed.

Study of the heulandite lattice [M. H. HEY, 1935, M. H. HEY, and F. A. BANNISTER, 1934, W. H. TAYLOR, 1934, U. VENTRIGLIA, 1955, J. WYART, 1933] has revealed that the $(Si, Al)O_4$ tetrahedra constitute six-unit rings which in their turn form a honeycomb-type structure parallel to [100]. Parallel to [001], on the other hand, there are minute channels bounded by five- and eight-unit rings respectively. The cations occupy all these cavities. Just like the water molecules, they are free to move about rather than having a fixed position.

Derivatograms reveal that heulandite loses its water content in three steps *(Fig. 6)*, with peaks at 220, 420 and 520 degrees centigrade on the DTA graph. The weight loss values observed at the end of these endothermic processes were

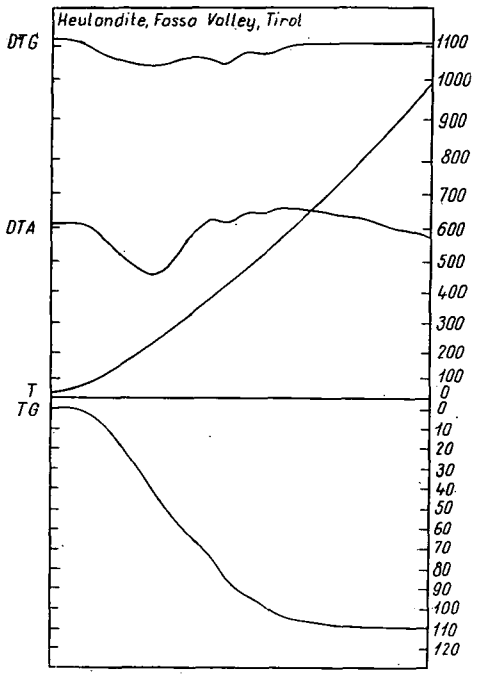


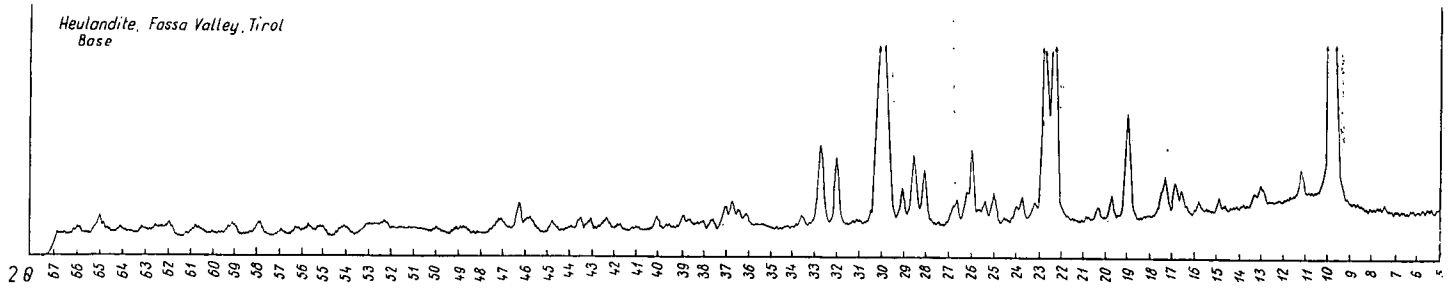
Fig. 6. Derivatogram of heulandite with DTG, DTA, T and TG graphs

1,83	percent at	110 degrees centigrade,
8,57		360
3,00		490
2,17		780
15,57	percent.	

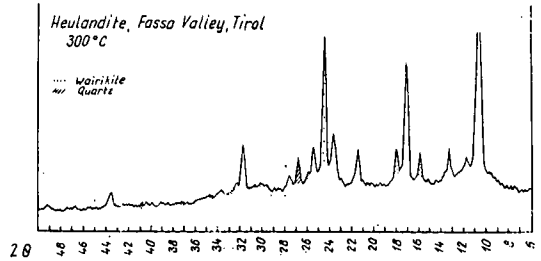
X-ray diffractometry has been performed on both the unheated sample *(Fig. 7/a)* and on the samples heated at 300, 400, 600, 800 and 1000 degrees, [M. KOIZUMI and R. ROY, 1960] state heulandite to have been decomposed into wairikite and SiO_2 at 320 degrees. In our sample heated at 300 degrees, we could demonstrate the presence of these substances, although the d/hkl values of heulandite could still be identified *(Fig. 7/b)*. The sample heated at 400 degrees included a substantial amorphous phase, indicating that the mineral had essentially been decomposed up to that temperature, but some of the d/hkl values of heulandite were still present, although with considerable angle shifts. Heulandite heated at 600 to 800 degrees centigrade becomes completely amorphous and turns at 1000 degrees into a feldspar of about bytownitic composition *(Fig. 7/c)*.

The infra-red spectrum of heulandite includes bands of absorption between 3000 and 3700 cm^{-1} and a peak at 1640 cm^{-1}, indicating the presence of water, and bands occurring between 400 and 1500 cm^{-1}, characteristic of the silicate lattice and agreeing well with data found in literature [R. G. MILKEY, 1960, H. MOENKE, 1961]. As there are two weak peaks at 3620 cm^{-1} and in the 3400 to 3490 cm^{-1}

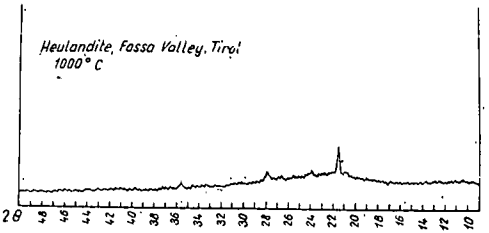
Fig. 7. X-ray diffractometry patterns of heulandite



a) unheated



b) heated at 300° C



c) heated at 1000° C

range, respectively, one may think of an incomplete agreement of the water contents. (Infra-red spectrograms of the heated samples have been prepared with nujole.) The absorption band due to water in heulandite heated at 300 degrees centigrade is characterized by a peak at about 3600 cm^{-1}, that of the sample heated at 400 degrees, by a broad band in the same range. The absorption band at about 1600 cm^{-1} vanishes from the diagram of this latter sample. The absorption band between 400 and 1200 cm^{-1}, due to the silicate structure, does not change up to 400 degrees centigrade, but there it becames very broad and vague. The sample heated at 1000 degrees turned out entirely waterless; its silicate lattice is that of a feldspar *(Fig. 8)*.

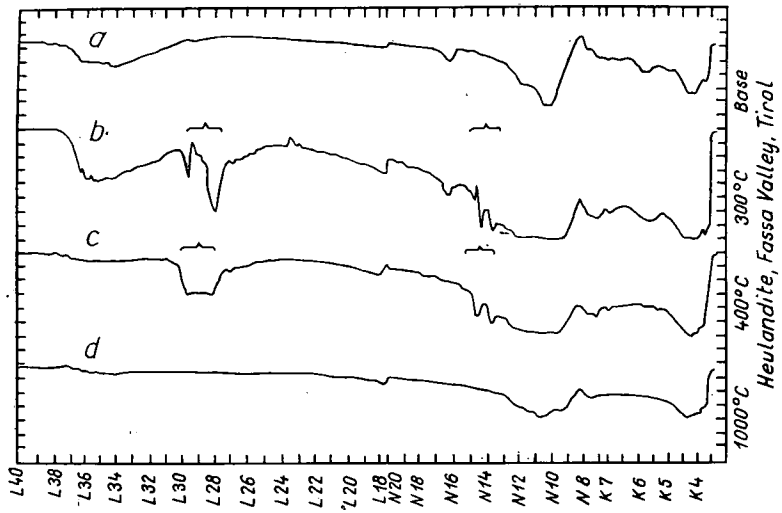


Fig. 8. Infra-red spectrograms of heulandite
a) unheated
b) heated at 300° C
c) heated at 400° C
d) heated at 1000° C

TABLE 3

Anal: dr. Simó, B.

	Heulandite, Fassa Valley, Tirol
SiO_2	59,62 %
TiO_2	0,00
Al_2O_3	14,44
Total iron	0,68
MnO	0,00
MgO	0,06
CaO	6,52
Na_2O	1,52
K_2O	0,80
Total water	15,39
P_2O_5	0,00
CO_2	0,00
	99,03 %

On *the* basis of the above *chemical composition (Table 3)* referred to the waterless substance and to 18 O_2, one ontaines the formula

$$Na_{0,346}\ K_{0,117}\ Mg_{0,011}\ Ca_{0,814}\ Fe_{0,058}\ Al_{1,980}\ Si_{0,942}\ O_{18}$$

and taking into account the water content, too

$$Na_{0,346}\ K_{0,117}\ Mg_{0,011}\ Ca_{0,815}\ Fe_{0,058}\ Al_{1,981}\ Si_{6,947}\ O_{18} \cdot 5{,}986\ H_2O.$$

A diagram composed of *the data on regeneration (Fig. 9)* shows that the mineral is consistently able to resorb up to 200 degrees centigrade more water than it loses on heating, although it loses more water at higher temperatures (that is, its regenerative ability increases with rising temperature). Heating at 250 degrees and above may bring about a lattice change wich precludes any further intake of water. Nevertheless, further heating causes some weight loss, indicating that the mineral still contains some water. Above 400 degrees it turns, however, into a substance that is hardly capable even of superficial adsorption.

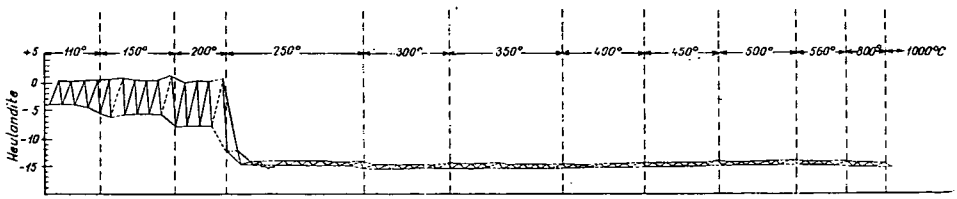


Fig. 9. Regeneration graph of heulandite

On the basis of the above-described *results* one may state concerning the relationship between lattice structure and water content in heulandite that part of the water content is fixed whereas the rest may move relatively freely in the cavities of the lattice. It is this latter part wich escapes freely and is as freely substituted; in some instances water intake may exceed the preceding water loss.

Heating above 250 degrees centigrade destroys the regenerative ability of heulandite. According to J. WYART, [1933], the escape of water above 210 degrees entails a substantial change in structure. The dimensions of the unit cell also change. According to ROSKOWA [1962], water occurs in layers and is in some way bound to the cations. She also thinks that the removal of these water molecules is most likely above 200 degrees.

The d/hkl values of heulandite heated above 300 degrees are shifted partly to lower, partly to higher angles, thus confirming the above statement.

In the present author's opinion, water escaping at 250 degrees plays some part also in the layered structure of heulandite, perhaps even in bonding together the layers, as its removal brings about a change in the lattice, a ceasing of the regenerative ability. It is at 300 degrees that the transformation into wairikite and SiO_2 begins. Hence, the peak reaching up to 360 degrees on the DTA graph reflects both the lattice change and the loss of almost 9 percent of water. As to water still present at 500 to 600 degrees centigrade, the author thinks that it may be in a bond, resembling that of water in gels, in the considerable amorphous phase evinced by X-ray diffractometry. Near collapse of the lattice at those temperatures precludes any regeneration.

Up to 300 degrees, heulandite is a fairly high-grade adsorbent, and its regeneration even improves up to 250 degrees centigrade.

Scolecite. Two scolecite specimens from two different localities exhibited a highly similar behaviour under the investigative procedures employed.

Tracing the water loss process of scolecite by means of the derivatograph, one obtains a TG graph indicating measurable water loses as high up to 900 degrees centigrade. Both the DTA and DTG graphs bear four sharp and two flat endothermic peaks. The sharp peaks occur between 200 and 220, at 470, between 490 and 520, and between 540 and 560 degrees centigrade, respectively; the flat peaks reach their maxima at 690 and 840 degrees respectively. The weight losses corresponding to the terminal ends of the peaks are as follows:

Scolecite

Attlitztal, Switzerland		Boulands Tundra, Iceland	
360 °C	4,57—4,37 %	374 °C	4,70—4,70 %
455 °C	6,34—1,77	480 °C	6,4 —1,70
520 °C	9,19—2,85	540 °C	9,3 —2,9
571 °C	9,83—0,64	580 °C	10,25—0,95
765 °C	11,86—2,03	765 °C	12,47—2,22
950 °C	13,39—1,53	970 °C	13,60—1,13
	13,39 %		13,60 %

X-ray diffractometry has been applied besides the original sample to samples heated at 350, 400, 500, 800 and 1000 degrees centigrade. The results of these as well as of the other examinations (chemical analysis, infra-red spectroscopy, deriva-

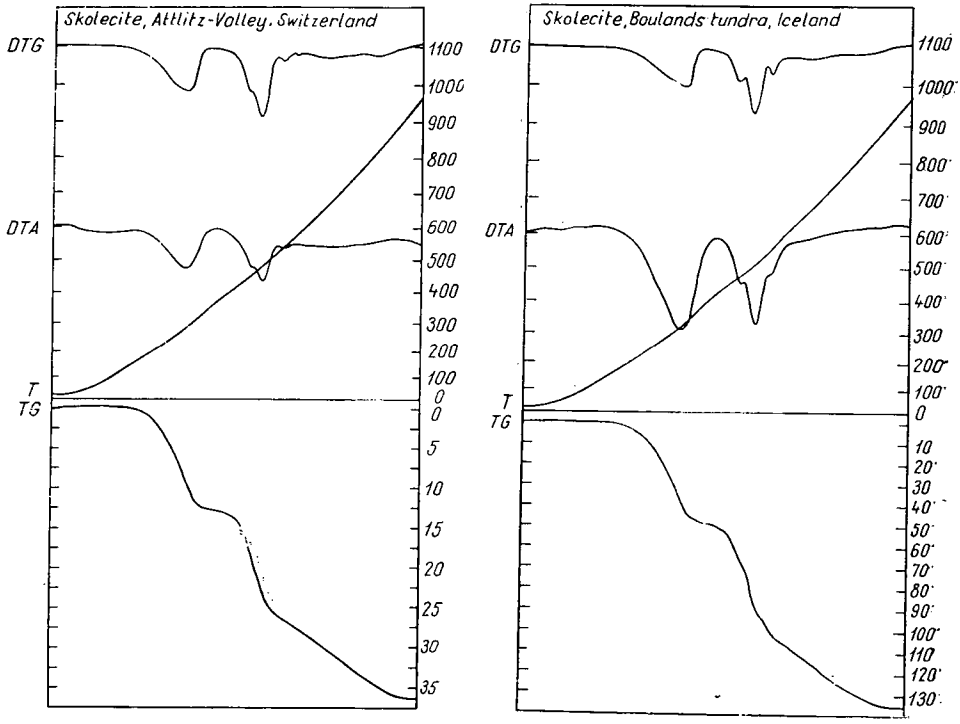
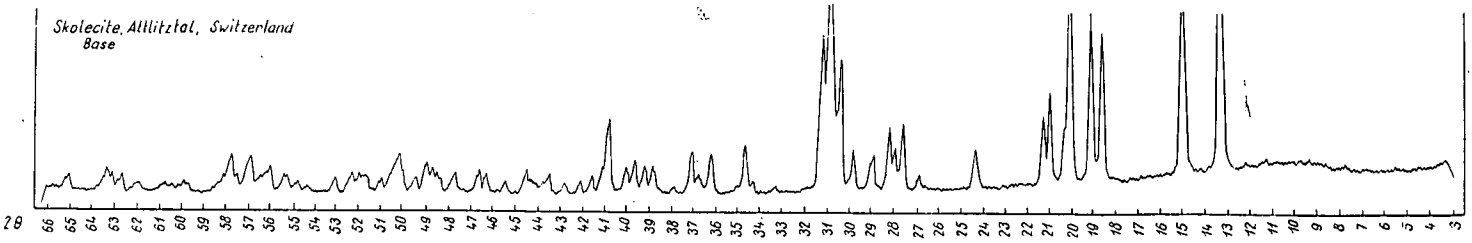
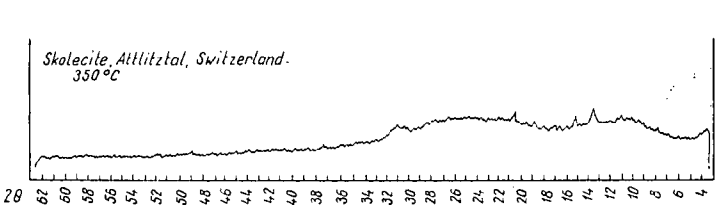


Fig. 10. Derivatogram of scolecite with DTG, DTA, T and TG graphs

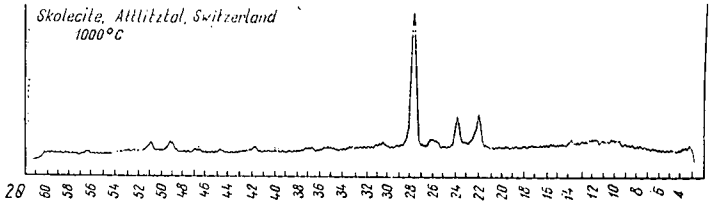
Fig. 11. X-ray diffractometry patterns of scolecite



a) unheated



b) heated at 350° C



c) heated at 1000° C

tograms) all show a fairly good agreement between the two specimens and with data encountered in literature *(Fig. 11/a)* and have called the attention to certain specific, properties, unobserved so far, of scolecite. In samples heated at 350 degrees *(Fig. 11/b)*, one or two principal d/hkl values of scolecite could still be identified besides a substantial amount of amorphous substance. The samples heated at 400, 500 and 800 degrees were completely amorphous, and the mineral turned into anorthite at 1000 degrees *(Fig. 11/c)*.

Infra-red spectrograms have been prepared on the unheated samples and on the samples heated at 350, 400, 500 and 1000 degrees, respectively of both specimens. The unheated spectrogram *(Fig. 12)* is in full agreement with those found in literature [R. G. MILKEY, 1960] concerning both absorption bands, that of 3100 to 3700 cm^{-1} as well as that of 400 to 1200 cm^{-1} (this latter being characteristic of the silicate lattice). The first band clearly indicates by six narrow bands of absorption the discrete bond energy levels of water in scolecite as opposed to heulandite and gmelinite. In the silicate lattice, both OH—Al^{3+} 930 cm^{-1} and 910 cm^{-1} are clearly defined. After heating at 350 degrees, the above-mentioned water peaks are still distinct and there is also the common water band at 1620 to 1640 cm^{-1}. In the sample heated at 400 degrees, the intensity of the peak at 1640 cm^{-1} is substantially decreased. The peaks between 3100 and 3700 cm^{-1} broaden into bands but there are still four distinct peaks indicating the presence of water in a fairly

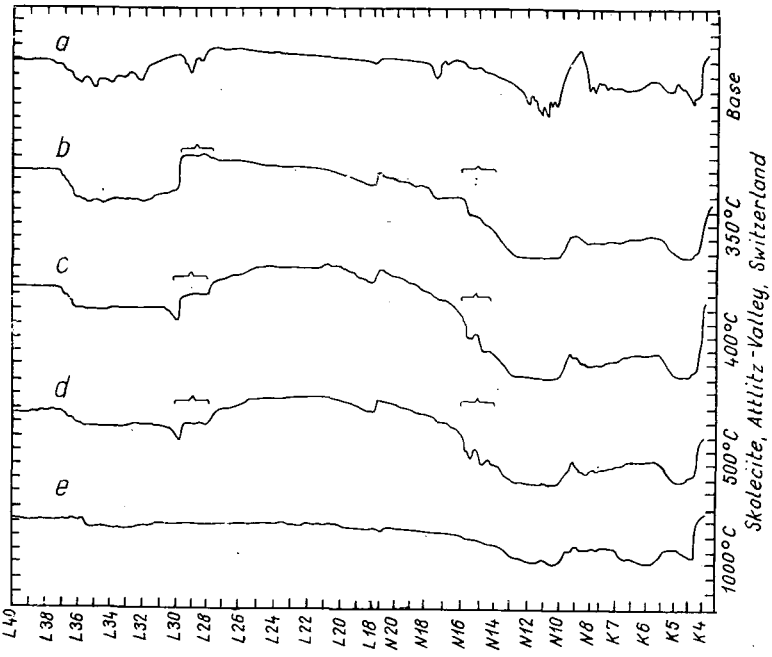


Fig. 12. Infra-red spectrograms of scolecite from Attlitz-Valley, Switzerland
a) unheated
b) heated at 350° C
c) heated at 400° C
d) heated at 500° C
e) heated at 1000° C

strong bond. At 500 degrees, the peak at 1640 cm^{-1} disappears, but the one at 3600 cm^{-1} is still weakly visible. At 1000 degrees, a diagram representative of anorthite turns up.

The results of the *chemical analyses* are given below *(Table 4).*

TABLE 4

Anal.: dr. Simó, B.

Skolecite

	Boulands Tundra Iceland	Attlitz Valley Switzerland
SiO_2	46,23 %	46,00 %
TiO_2	0,00	0,00
Al_2O_3	26,40	27,12
Total iron	0,00	0,00
MnO	0,00	0,00
MgO	0,03	0,01
CaO	14,32	14,30
Na_2O	0,35	0,32
K_2O	0,00	0,00
Total water	13,59	13,35
P_2O_5	0,00	0,00
CO_2	0,00	0,00
	100,92 %	101,10 %

These results yield the following structural formula, referred to 10 O_2 and the waterless substance: Attlitz Valley, Switzerland:

$$Na_{0,040}\ Ca_{0,987}\ Al_{2,055}\ Si_{2,594}\ O_{10}$$

Boulands Tundra, Iceland:

$$Na_{0,044}\ Ca_{0,990}\ Mg_{0,003}\ Al_{2,010}\ Si_{2,984}\ O_{10}$$

Taking into account the water content, too, this modifies to Attlitz Valley, Switzerland:

$$Na_{0,041}\ Ca_{0,997}\ Al_{2,077}\ Si_{2,985}\ O_{10} \cdot 2{,}893\ H_2O$$

Boulands Tundra, Iceland:

$$Na_{0,044}\ Ca_{0,995}\ Mg_{0,003}\ Al_{2,022}\ Si_{3,001}\ O_{10} \cdot 2{,}943\ H_2O$$

Data of regeneration. As distinct from heulandite and gmelinite, scolecite does not lose any of its water content up to 200 degrees centigrade and is incapable of absorbing more water than it has lost on dehydration. At 200 degrees there is a weight loss of about 4 per cent; at 250 degrees, weight loss amounts to 11 per cent occurs, but whereas the water lost at 200 degrees may be resorbed, that lost at 250 degrees may not. At higher temperatures the substance gradually loses water up to 1000 degrees. This water loss is incapable of regeneration *(Fig. 13).*

The above *results* concerning the behaviour of scolecite permit to draw the following conclusions as to the relationship between its lattice and water content:

The water content of scolecite is, as that of the rest of the natrolite group, in a "crystal-water-type" bond which is reflected by several bands of absorption in the infra-red spectrum. DTA, DTG and infra-red spectroscopy all reveal that water escapes in six steps. Differences in water bond force are reflected in a non-

uniform rate of water escape. Most of water (about 6 percent) leaves up to 350 degrees, which temperature is also the upper limit of the thermal stability of the lattice.

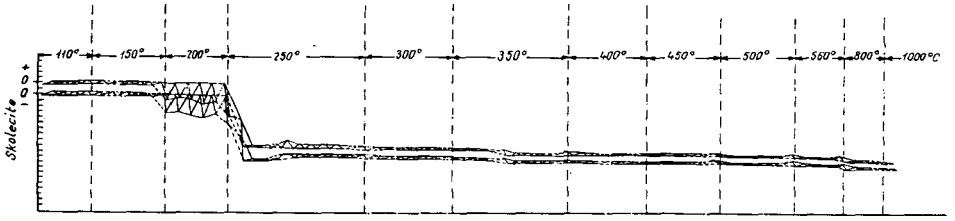


Fig. 13. Regeneration graphs of scolecites

KOIZUMI and ROY [1960] state scolecite to decompose into anorthite, wairikite and H_2O at 300 degrees centigrade. In the experience of the present author, this decomposition reaches a fully amorphous stage at 350 degrees. Hence, water escaping up to that temperature is an essential element of the lattice, as its removal entails the collapse of the structure. X-ray diffractometry evinces a completely amorphous substance above 350 degrees, and the infra-red spectra also indicate the collapse of the silicate lattice. However, since the presence of further amounts of water is proved by further peaks on the DTA and DTG graph, respectively and well-defined bands of absorption on the infra-red spectrogram, it is to be supposed that lattice collapse is not complete after all and that there remains a fine-grained crystalline phase capable of binding water at various energy levels. This water gives three sharp endothermic peaks at 455, 480 and 540 degrees centigrade, that is, at fairly well-defined bond energy levels, whereas the remaining water, about 3 per cent up to 900 degrees, may occur in a bond resembling that of water in a silica gel. In the course of further research the author deems it of particular importance to investigate this amorphous phase, in order to clear up the positions and eventually also the bond type of this high-temperature residual water content.

ABSTRACT

The author has applied the derivatograph, the X-ray diffractometer, and the infra-red spectrograph to the study of three zeolites representing three different lattice types, gmelinite, heulandite and scolecite. She has studied their regeneration and chemical composition as well. Besides the natural minerals, some of the above-named experiments have been performed also on samples heated at various temperatures.

The silicate lattice of gmelinite does not change up to 800 degrees centigrade. At 1000 degrees it turns into an oligoclase feldspar. Most of its water content occupies the smaller cavities of the lattice, being bound neither to the cations, nor to any specific lattice points. Some of it is held in the larger cavities, most of which are occupied by the cations, and is bound to these latter. The mineral is highly absorptive up to the complete collapse of the lattice at 800 degrees centigrade: its optimum adsorption is attained after heating at 250 degrees.

The silicate lattice of heulandite is stable up to 200 degrees centigrade. Upon heating at 300 degrees, one observes a lattice deformation that has taken place at a slightly lower temperature and the presence of some wairikite and quartz. At 400 degrees it is the amorphous phase that dominates the picture, with one or two of the d/hkl values of heulandite still present. At a higher temperature the substance grows roentgenographically amorphous and at 1000 degrees it is transformed into a bytownitic feldspar. A large part of its water content constitutes an essential element of the lattice, presumably intercalated between the layers and playing a role in holding them to-

gether. The loss of this type water at 250 degrees means the simultaneous loss of the regenerative ability. About 5 percent of the original water content stays behind and only leaves at 400 degrees; it is presumably bound to the amorphous phase like the water bound by gels.

The silicate lattice of scolecite can still be identified at about 400 degrees centigrade. Above that, this mineral also turns roentgenographically amorphous. Its transformation into metascolecite and the loss of one mole of its water content takes place by the end of the first endothermic peak on the DTA graph, that is, up to 400 degrees. If heated at 200 degrees, the mineral preserves its ability to regenerate: it is presumably at this temperature that its transformation into metascolecite takes place. At 1000 degrees centigrade it turns into anorthite. Its water molecules are bound to well-defined points of the lattice. Up to 570 degrees a second mole of water escapes, giving rise to a further sharp endothermic peak. X-ray patterns suggest that this water is bound to a crystalline phase of a grain so fine as to go undetected on the diffraction patterns. The third mole of water leaves above 600 degrees from a completely amorphous (gel) phase.

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ÜBER DAS VORKOMMEN VON GORCEIXIT IM ARGILLISIERTEN PHONOLITH VON NORDWESTBÖHMEN

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Auszug: Es wird über ein Vorkommen von Gorceixit in Nordwestböhmen berichtet. Das Mineral wurde in einem intimen Gemenge mit Kaolinit in tonigen Gesteinen, die aus Phonolith entstanden, entdeckt. Auf Grund eingehender Untersuchung wird die röntgenographische, thermoanalytische und chemische Charakteristik dieses Minerals gegeben. Für seine Entstehung wird die Veränderung von Phonolith und der in diesem Gesteine vorkommenden Äderchen von dichten Zeolithen als Ursache betrachtet.

EINLEITUNG

Das erste Vorkommen von Gorceixit, einem wasserhaltigen Barium-Aluminium Phosphat von der wahrscheinlichen Zusammensetzung $BaAl_3H(OH)_6(PO_4)_2$ (H. STRUNZ, 1957), in Europa wurde von L. TOKODY, J. MÁNDY und S. NEMES-VARGA (1957) aus der berühmten Lagerstätte Baia Sprie (Felsőbánya) in Rumänien festgestellt. Erst sechs Jahre später wurde ein weiterer europäischer Fundort dieses interessanten Minerals ermittelt, und zwar in Frankreich, im Massiv von Colettes (Allier) von J. NICOLAS und A. DE ROSEN (1963).

Ausserhalb des europäischen Kontinents hat man Gorceixit abgesehen von den Originallokalitäten in Brasilien (E. HUSSAK, 1899) an mehreren Stellen in Amerika (S. BRACEWELL, 1946; C. MILTON *et alii*, 1958; E. J. YOUNG, 1958), Afrika (A. M. MACGREGOR, 1941; N. R. JUNNER, 1946) und Asien (E. A. ANKINOWITSCH, N. I. SILANTJEWA, 1959) gefunden. Beim Vergleich der Art des Vorkommens scheint die zuerst von C. MILTON *et alii* (1958) ausgedrückte Meinung über die verhältnismässige Häufigkeit dieser Mineralart berechtigt zu sein. Der Grund dafür, dass Gorceixit der Aufmerksamkeit früherer Forscher entging und für ein seltenes Mineral gehalten wurde, besteht in den seinerzeit ungenügend empfindlichen Untersuchungsmethoden, die meist nicht imstande waren, dessen unauffallende und manchmal submikroskopische Existenz nachzuweisen.

MINERALOGISCHE CHARAKTERISTIK DES GORCEIXIT AUS NORDWESTBÖHMEN

Gorceixit in Nordwestböhmen wurde anlässlich eines Laboratoriumstudiums der Stufen ermittelt, welche den Erkundungsbohrungen im Gebiete von Most-Chomutov- Teplicebecken entstammten. Ursprünglich wurde das Material auf die Natur und den Gehalt von Tonmineralen untersucht, wobei Gorceixit in einer intimen Verwachsung mit Kaolinit identifiziert wurde.

Gorceixit wurde aus dem Material von sieben Bohrungen einwandfrei festgestellt. Alle diese Bohrungen befanden sich in der Umgebung von Malé und Vysoké Březno in der Nähe von der Stadt Most. Das Vorkommen dieses Minerals ist auf das Vorhandensein von kleinen bis etliche Zentimeter mächtigen Äderchen beschränkt, die in vollkommen argillisiertem Phonolith hervortreten. Die Farbe dieser Äderchen ist mehr oder weniger der Farbe des Phonoliths ähnlich: weiss oder hellgrau, manchmal ein wenig bläulich, rot bis rötlich braun. Die Masse des argillisierten Phonoliths ist unter der Oberfläche verborgen. In Hinsicht auf die Dimensionen des Phonolithkörpers wurde es von F. Holy und J. Kavka (1962) „Bořicky's Berg"* genannt.

Auf die Anwesenheit von Gorceixit wiesen vor allem die Ergebnisse des Röntgen- und Spektralstudiums der betreffenden Proben hin. Die erhaltenen Angaben gaben Anlass zu einer kombinierten Untersuchung, bei der alle zur Verfügung stehenden Methoden eingeschaltet wurden.

Das *mikroskopische Bild* der Proben, die Gorceixit enthalten, trug sehr wenig zur näheren Charakteristik dieses Minerals bei. Im Polarisationsmikroskop beobachtete man nur eine feinkörnige Masse; auf das Vorhandensein von Gorceixit konnte man nur auf Grund der erhöhten Brechungsindices schliessen, deren Werte zwischen den Werten für reinen Kaolinit ($n_\alpha = 1{,}553—1{,}563$; $n_\gamma = 1{,}560—1{,}570$) und Gorceixit ($n' = 1{,}61—1{,}66$) liegen. So wurde z. B. der mittlere Brechungsindex einer gleichzeitig auch durch andere Methoden untersuchten Probe mittels der Immersionsmethode als $1{,}596 \pm 0{,}005$ gemessen. Im Elektronenmikroskop wurden für Kaolinit typische pseudohexagonale Plättchen sichtbar, ferner kamen unregelmässige, manchmal quadratische Formen vor, die vermutlich für Gorceixit charakteristisch sind.

Das *röntgenographische Studium* erwies sich als sehr erfolgreich, da man sowohl die gesamte mineralogische Zusammensetzung der Gorceixit enthaltenden Proben feststellen als auch eine nähere Charakteristik des Röntgenpulverdiagrammes von Gorceixit erhalten konnte. Den Ergebnissen der Röntgenuntersuchung gemäss kommen nebst einem gut geordneten triklinischen Kaolinit noch kleine Mengen von Hämatit, Goethit, Quarz und wahrscheinlich auch Anatas in diesen Proben vor. Zieht man alle diese Minerale in Erwägung und lässt man die entsprechenden Diffraktionslinien auf den erhaltenen Pulverdiagrammen *(Abb. 1.)* weg, gehören die übriggebliebenen Diffraktionslinien mit grösster Wahrscheinlichkeit Gorceixit. Dies wurde durch Vergleich mit den in der Literatur existierenden Röntgenangaben (E. A. Ankinowitsch, N. I. Silantjewa, 1959; J. Nicolas, A. de Rosen, 1963; L. Tokody *et alii*, 1957) und mit den zu diesem Zweck hergestellten Pulveraufnahmen von Gorceixit aus der Originallokalität Rio Abaete in Brasilien und aus dem Massiv von Colettes in Frankreich mit positivem Ergebnis überprüft.

* Zu Ehren des hervorragenden tschechischen Petrographen des vorigen Jahrhundertes E. Bořicky (1840—1881).

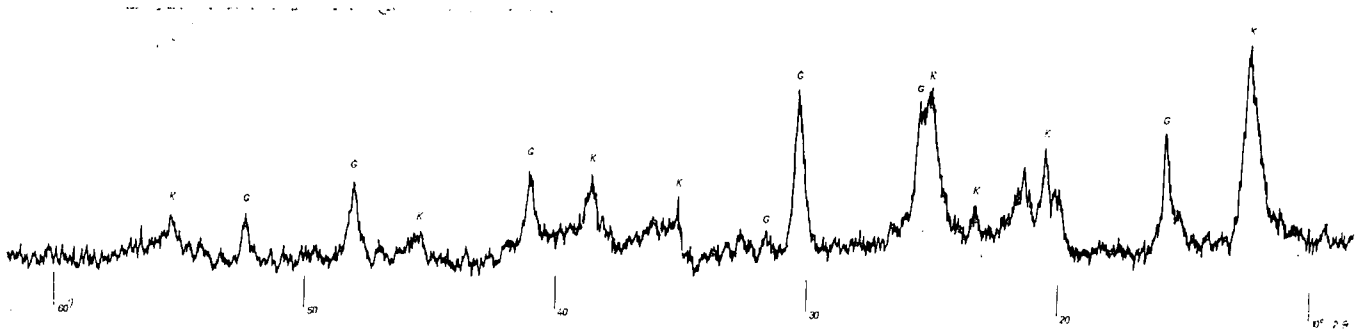

Abb. 1. Diffraktogram einer Gorceixitführenden Probe aus der Umgebung von V. Březno (G= =Gorceixit, K=Kaolinit).

TABELLE 1

Röntgenographische Daten für Gorceixit

hkl	1			2		
	d gem.	d ber.	I	d gem.	d ber.	I
101	5,73	5,72	9	5,68	5,69	s. st.
110	3,519	3,511	8	3,49	3,495	s. st.
201		2,992		2,974	2,978	m.
	2,978		10 B			
113		2,978		2,945	2,959	s. s. st.
202	2,855	2,859	3	2,840	2,845	m.
204	2,475	2,466	2	2,445	2,450	s. s. schw.
115	2,449	2,433	3			
211	2,271	2,277	5	2,268	2,267	schw.
212	2,215	2,217	6	2,206	2,206	st.
300	2,021	2,027	3	2,017	2,018	s. s. schw.
214	2,013	2,018				
303	1,905	1,907	7	1,897	1,897	st. B.
220	1,756	1,755	6	1,748	1,747	st.
311	1,675	1,678	2	1,665	1,670	s. schw.
312		1,653			1,646	
	1,651		< 1	1,645		s. s. schw.
119		1,653			1,638	
401		1,514			1,507	
	1,510		1	1,503		s. s. schw.
315		1,508			1,500	
402		1,496			1,489	
	1,490		3	1,485		s. st.
226		1,489			1,480	

1 — Gorceixit aus Rio Abaete, Brasilien: $a_0 = 7{,}02$ Å, $c_0 = 16{,}87$ Å
2 — Gorceixit, M. Březno: $a_0 = 6{,}98$ Å, $c_0 = 16{,}69$ Å

Der Versuch um eine Indexation der vorhandenen Diffraktionslinien von Gorceixit erfolgte zuerst auf Grund der Elementarzelle von L. TOKODY, J. MÁNDY und S. NEMES—VARGA (1957). Dies führte jedoch zu keiner guten Übereinstimmung zwischen den gemessenen und berechneten Werten. Da die meisten Autoren Gorceixit für ein Mitglied der Crandallit-Reihe halten, wurde zur Indexation die vorausgesetzte Analogie zwischen den Röntgenpulveraufnahmen von Gorceixit und Crandallit verwendet. Nach der Indexation von einer Röntgenaufnahme von Crandallit aus Utah (J. P. OWENS, Z. S. ALTSCHULER, R. BERMAN, 1960) auf Grund von bekannten Gitterkonstanten gelang es auch für die Diffraktionslinien beider Pulveraufnahme, die in *Tab. 1.* angeführt sind, entsprechende *hkl* — Indices und Gitterkonstanten zu finden. Dieser Indexation zufolge ist Gorceixit aus Nordwestböhmen hexagonal mit Gitterkonstanten $a_0 = 6{,}98$ Å, $c_0 = 16{,}87$ Å, die im Vergleich zu den Gitterkonstanten von Gorceixit aus Rio Abaete ($a_0 = 7{,}02$ Å, $c_0 = 16{,}87$ Å) niedriger sind.

TABELLE 2

Chemische Analysen drei Gorceixitführenden Proben aus der Umgebung von M. und V. Březno
(Analytiker Dr. P. POVONDRA)

	1		2		3	
	a	*b*	*a*	*b*	*a*	*b*
SiO_2	29,31		30,69		30,43	
TiO_2	2,22		1,91		3,41	
Al_2O_3	35,54	34,00	34,44	35,55	33,77	30,09
Fe_2O_3	1,26		5,73		2,40	
MnO	Spuren		Spuren		Spuren	
MgO	Spuren		Spuren		Spuren	
CaO	0,23	0,73	0,10	0,42	0,18	0,68
SrO	0,10	0,31	0,08	0,34	0,10	0,38
BaO	5,04	16,08	4,29	18,18	6,20	23,44
SO_3	0,44	1,40	0,39	1,65	0,35	1,32
P_2O_5	8,56	27,28	6,26	26,53	7,00	26,47
H_2O+	15,56	20,20	13,94	17,33	14,71	17,62
H_2O-	1,16		1,15		1,39	
	99,42%	100,00%	98,98%	100,00%	99,94%	100,00%

a — Gesamtanalyse *b* — Analyse von Gorceixit

Die *Differentialthermokurven* der Proben mit Gorceixitgehalt wiesen neben den Thermoeffekten von Kaolinit ein kleines exothermales Maximum bei 840—860 °C auf *(Abb. 2)*. Die Grösse dieses Maximums ist veränderlich und entspricht wahrscheinlich der Menge von Gorceixit in den untersuchten Proben. Andere thermische Reaktionen von Gorceixit, über die in der Literatur berichtet wurde (E. A. ANKINOWITSCH, N. I. SILANTJEWA, 1959; J. NICOLAS, A. DE ROSEN, 1963), scheinen von den thermischen Effekten des Kaolinit überdeckt zu sein.

Die qualitative Spektralanalyse und die *chemische Analyse (Tab. 2)* bestätigten die Identifikation von Gorceixit in den analysierten Proben. Nach der Subtraktion der auf andere Minerale entfallenden Anteile versuchten die Verfasser die chemischen Formel der analysierten Gorceixitproben mit folgenden Ergebnissen zu berechnen:

1 $(Ba_{0,522}\ Ca_{0,065}\ Sr_{0,015})_{0,602}\ Al_{3,321}(PO_4)_{1,913}\ (SO_4)_{0,087}(OH)_{5,254}\cdot 2{,}955\ H_2O$
2 $(Ba_{0,601}\ Ca_{0,038}\ Sr_{0,017})_{0,656}\ Al_{3,538}(PO_4)_{1,895}\ (SO_4)_{0,105}(OH)_{6,031}\cdot 1{,}864\ H_2O$
3 $(Ba_{0,785}\ Ca_{0,062}\ Sr_{0,019})_{0,866}\ Al_{3,032}(PO_4)_{1,915}\ (SO_4)_{0,035}(OH)_{4,913}\cdot 2{,}568\ H_2O$

ZUR GENESIS VON GORCEIXIT IN NORDWESTBÖHMEN

Aus den bisher beschriebenen Gorceixitvorkommen geht hervor, dass es sich um ein Mineral handelt, das unter der Wirkung der oberflächlichen Einflüsse enstand. Dies kann auch für das Vorkommen von Gorceixit in Nordwestböhmen angenommen werden. Die Äderchen, welche Gorceixit enthalten, waren wahrscheinlich auch im unveränderten Phonolith vorhanden und wurden aus den sogenann-

ten dichten Zeolithen zusammengesetzt (F. HOLÝ, J. KAVKA, 1962). Da in ähnlichen Gebilden bisher nur Analcim und Natrolith nebst kleineren Mengen von Kalzit und Aragonit ermittelt wurden, muss man die Quelle der chemischen Komponenten von Gorceixit anderswo suchen. Mit grösster Wahrscheinlichkeit wurden sie während des Prozesses der Argillisation aus der unmittelbaren Nähe, d. h. von den Mine-

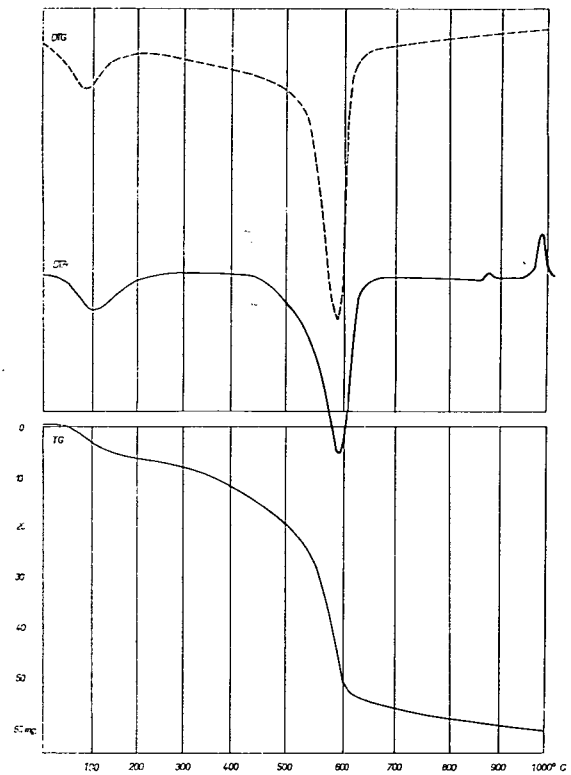

Abb. 2. Derivatogramm einer Gorceixitführenden Probe aus der Umgebung von V. Březno.

ralen des Phonolith geliefert. Barium, teilweise getrennt von Kalzium und Strontium wurde adsorptionsweise durch dichte Zeolithe aufgenommen. Durch die Reaktionen mit Lösungen, die Phosphat- und Aluminiumione enthielten, entstand Gorceixit. Die Veränderung der Zeolithe führte zur Enstehung von Kaolinit.

Herrn DR. J. KAVKA aus Prag gilt unser Dank für die wertvollen Informationen über die geologischen und petrographischen Verhältnisse der Lokalitäten von Gorceixit. Gleicher Dank gebührt Miss M. E. MROSE aus Washington und Mlle A. DE ROSEN und Prof. J. NICOLAS aus Paris die uns freundlicherweise mit Vergleichsproben versahen.

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DATA ON THE GEOLOGICAL AND MINERALOGICAL KNOWLEDGE OF LOWER PANNONIAN STRATA IN THE MISKOLC — GÖRÖMBÖLY AREA

by

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The Department of Silicate-Chemistry of the Central Institute for Silicate Research carried out, in the years 1962—1965, an exploration for raw-materials in the region of the Csoznyatető and Lengyelszótető heights, in the neighbourhood of Miskolc-Görömböly. In the course of prospecting — besides supplying the clay need of the "Hejőcsaba Cement and Lime Works" and the geological knowledge of the region — we obtained with the great scale examintation of materials, a detailed information about the mineralogical-petrographical setting of the Lower Pannonian formation in the southern region of Miskolc [GY. VITÁLIS—J. HEGYI, 1965].

GEOLOGICAL CONDITIONS OF THE AREA

Geological structure: The Csoznyatető-Lengyelszótető and their neighbourhood is situated in the hill region, built from Neogene top formations, east of the Mesosoic basement of the Bükk Mountains and west of the valley of the river Sajó *(Fig. 1)*.

Among the *Neogene* top formations, the Middle-Miocene sand, clay, sandstone and brown coal, further the upper-rhyolite tuff, andesite tuff and agglomerate as well as limestone and andesite-gravel, respectively, sand and clay belonging to the Sarmatian, finally Lower Pannonian sand and clay layers crop out on the surface.

Formations of the *Quaternary* are represented by Pleistocene brown-clay covering the greatest part of the area and by Holocene stream deposit and flood-area sediments filling the valley soles. [Z. SCHRÉTER 1925, 1939, 1943, 1960, T. TAKÁTS, 1964, GY. VITÁLIS—J. HEGYI, 1965].

Mountain Structure. The faulted forms are characteristical for the area. The NNE-SSW, NW-SE and N-S orientated faults, as already shown by the directions of surface drainage, cut the hilly region in smaller and greater blocks. Dip of the Neogene layers is generally 10—15° SE.

The areas present relief was formed in the Quaternary, by way of erosion. The effect of the erosion can mostly be seen beside the supposed SW-NE directed,

parallel faults. The valley top of the small, temporary waterflow with source on the Csoznyatető area, needs attention. The face of this was significantly changed during the heavy rainfalls of 1965 in comparison to the past drier years.

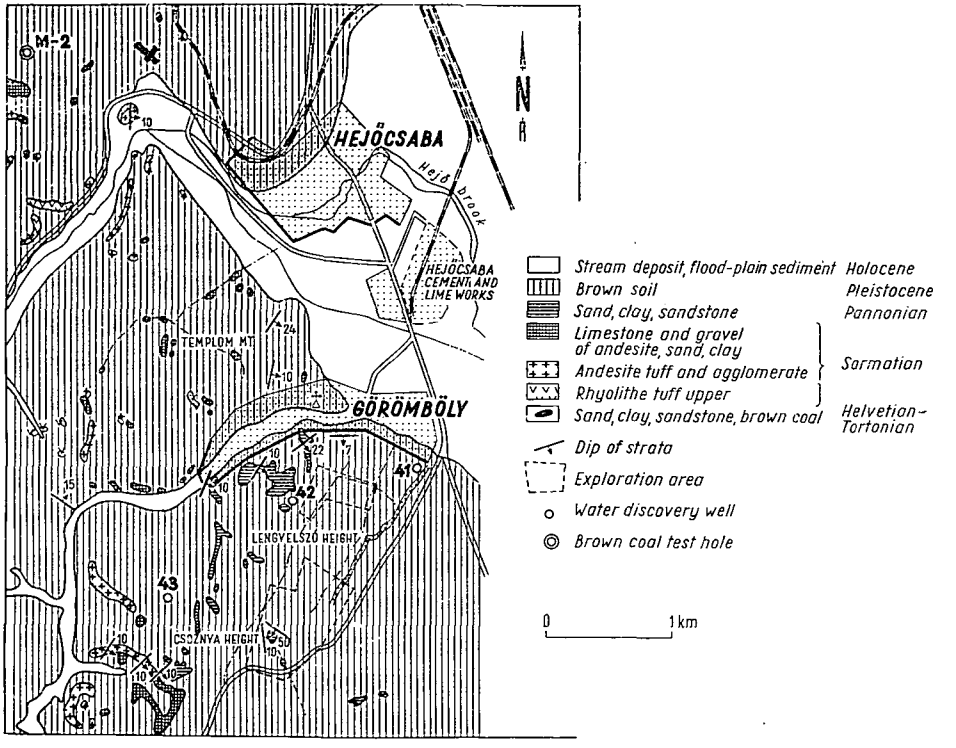

Fig. 1. Sketching geological map of the sorroundings of Miskolc-Görömböly (after Z. SCHRÉTER).

GEOLOGICAL SETTING OF THE PROSPECTED AREAS

Geological conditions. In the geological setting of the prospected Csoznyatető and Lengyelszótető area, Lower Pannonian and Pleistocene formations are taking part.

The *Lower Pannonian formation* explored by 10—30 m deep borings, contains clastic sedimentary rocks of varied petrographical development. Yellow, brown and grey coloured silty clay, clayey silt, silt with rock flour, silty rock flour, sandy rock flour, sand with rock flour and (fine) sand layers are alternating with one another.

Upon the Lower Pannonian strata 0,4—9,2 m thick Pleistocene cover is deposited consisting mostly of brown, reddish brown, less brownish yellow and brownish grey silty clay, clayey silt and silt with rock flour. The Pleistocene cover of clayey development — being practically a useful material for the cement industry too, — are shown on the clay thickness map *(Fig. 3)* together with the clayey Pannonian layers.

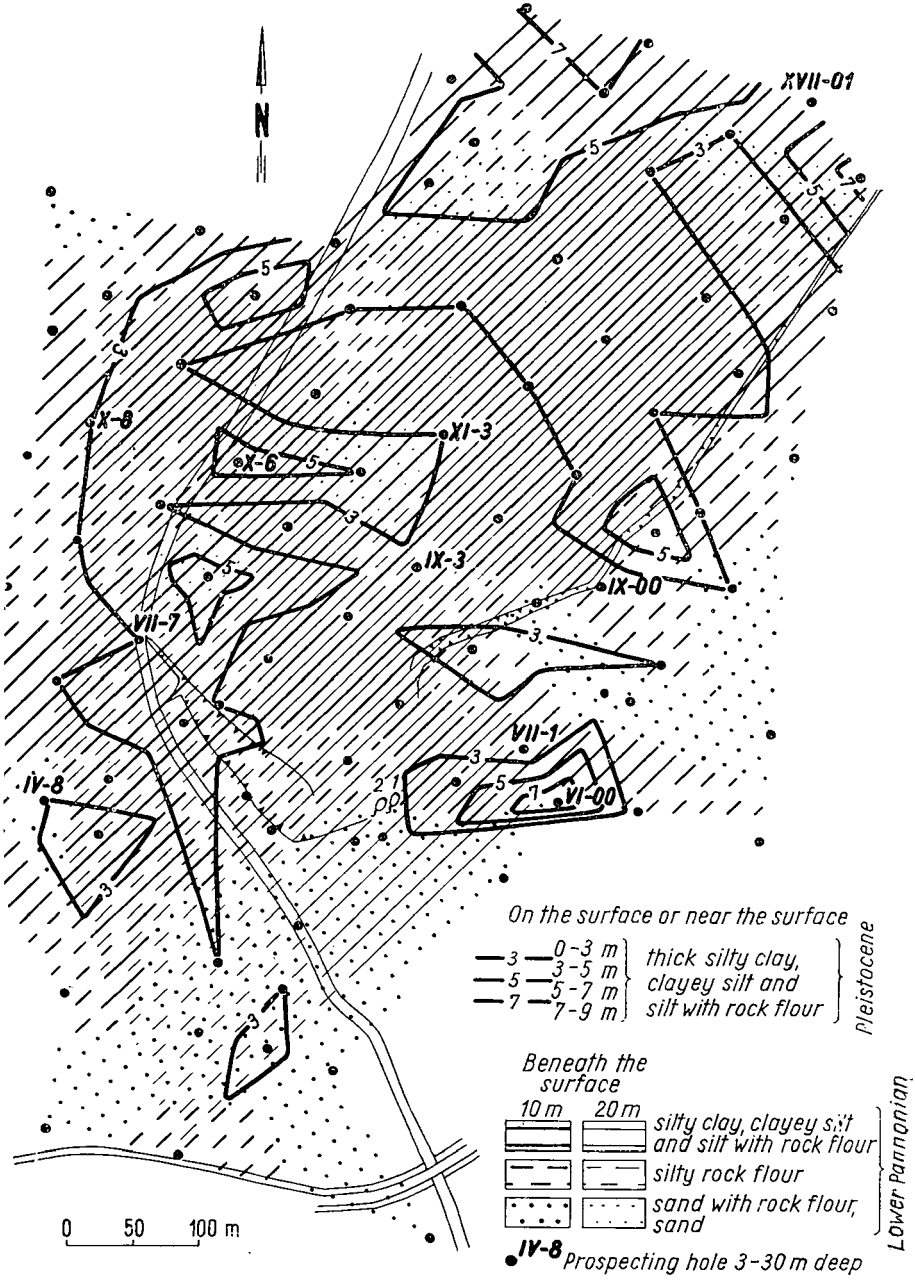

Fig. 2. Engineer-geological map of the Csoznyatető exploration area.

The general sequence of formations in the areas of clayey development, to the depth of 30 m, correlating well log datas, is the following:

Below the brown and mildy reddish brown clayey Pleistocene top formation, 3—5 m thick in average, generally to 20 m depth silty clay — in places with interbedded silty rock flour, — clayey silt and rock floured silt layers, characterized with yellowish brown or brownish yellow tint are alternating with one another. Under 20 m depth (till 30 m) grey coloured more uniformly developed silty clay, clayey silt or rock floured silt is bedded.

The grey coloured clayey layers bedded below 20 m represent a greater, connected sequence of strata toward the depth, based on the observations in the claypit of the Görömböly brick-works and on the log of the Miskolc — 42 watertesting well.

To justify the age of the layers, M. SZÉLES determined from the materials of the Csoznyatető VI-00, VII-7, IX-00, X-6, X-8, XI-3 and Lengyelszótető L-7 borings the following Ostracoda species:

Candona labiata ZAL., *Candona (Lineocypris) trapezoidea* ZAL., *Candona* sp., *Paracypria (Pontonella) acuminata* ZAL., *Amplocypris pannonica juv.* ZAL., *Amplocypris sinuosa* ZAL., *Amplocypris* sp., *Cyprideis heterostigma obesa* REUSS, *Cyprideis macrostigma* koll., *Cyprideis pannonica* MÉHES, *Cyprideis sulcata* ZAL., *Cyprideis* sp., *Loxoconcha* sp., *Leptocythere parallela* MÉHES, *Leptocythere* sp., *Hemicythere lörentheyi* MÉHES and *Hemicythere* sp.

The enumerated Ostracoda species give ample proof of the formations Lower Pannonian age.

The palynological investigations, made from the material of the Csoznyatető IV-8 and X-8 borings, during the complex examinations, are presented in the paper of Mrs. MARIA MIHÁLTZ [1966].

The geological conditions of the Csoznyatető prospecting area are displayed on the engineer-geological map *(Fig. 2)* designed upon the prospecting holes. It presents the thickness of the Pleistocene capping and the rock materials deposited at 10 and 20 m below the surface.

The total thickness of useful material is displayed on the isolith map of the clayey strata. The clay isolith map of the Lengyelszótető prospecting area is shown in *Fig. 3.*

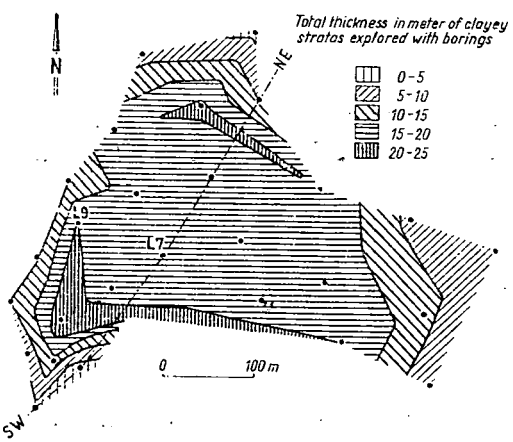

Fig. 3. Map of clay thickness of the Lengyelszótető exploration area

For the qualitative presentation of rock materials building up the area, SM (silicate module) maps for the Csoznyatető area and SM profiles for the Lengyelszótető area were constructed. These illustrate first of all the industrial utilisability of the raw-material and in the same time the petrographical setting of the area.

The SM maps of Csoznyatető were constructed with interpolation on the basis of the SM values of rock materials from 5, 10 *(Fig. 4)*, 15 and 20 m depths.

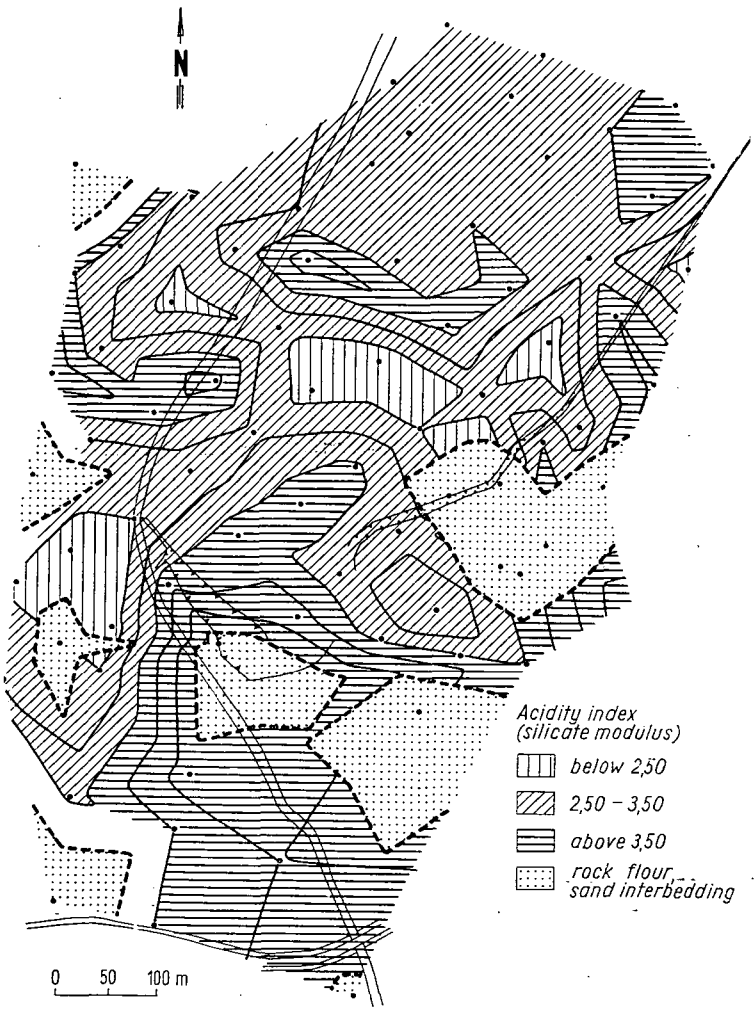

Fig. 4. SM (silicate module) map, 10 m below the surface, of the Csoznyatető exploration area.

The drawing of the boundaries of clay quality was coordinated with the geologic profiles from the same place, during the completing of the SM profiles of Lengyelszótető *(Fig. 6)*. So the geological and SM profiles are completing each other and give a good information — depending upon the possibilities — geologically and technologically.

STRUCTURAL AND BEDDING CONDITIONS

The structural and bedding conditions of both areas explored suit well in the frame outlined dealing with the mountain structure of the area.

The geological block-diagram *(Fig. 5)* of Csoznyatető — designed on base of test borings — and the profile on *Fig. 6*, chosen from geological sections made from the Lengyelszótető area, illustrate excellently the geological and bedding conditions.

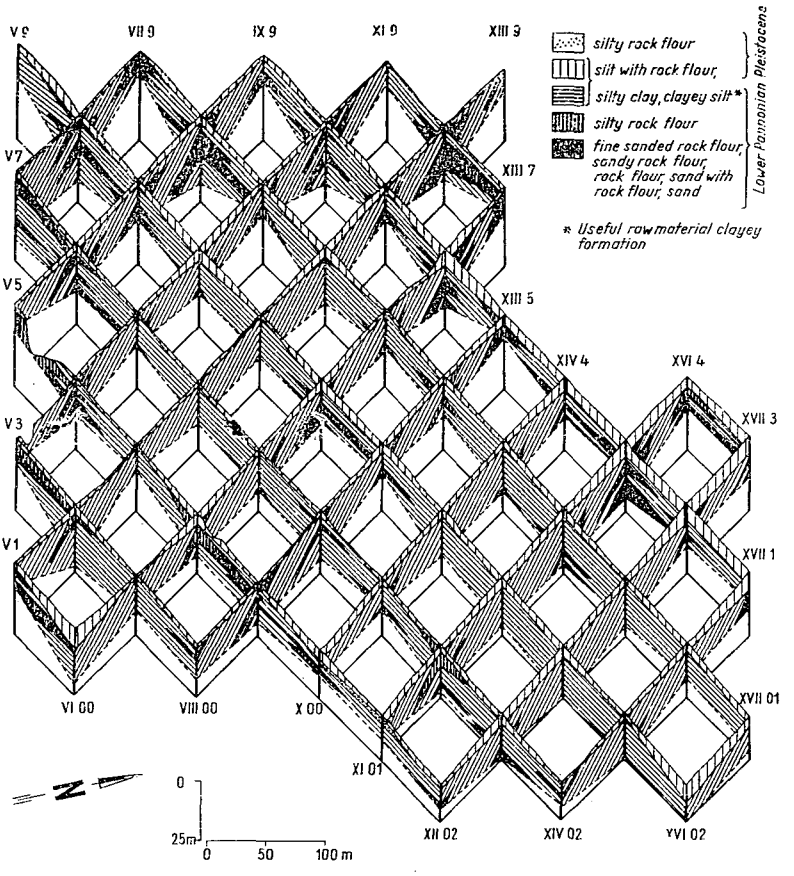

Fig. 5. Geological block diagram of the Csoznyatető exploration area

The dip values, by designing the block diagram and other profiles were taken into account with the average SE (135°) direction — characteristic of the area, and with 10°—15° angle of dip.

The silty clay, clayey silt and silt with rock flour strata are shown on the enclosed maps and profiles together and united as clayey layers — as useful raw-materials used in the cement-industry. The structure and bedding of sandy-clayey developed strata is to be seen in excellent outcrops of the clay mine in the Görömböly brick-

yard. In the series several faults and, mostly in the sandy developed layers, diagonal cross-beddings are to be seen. It is supposed on this base that the same conditions are to be found in the neighbourhood of the outcrop, in the area explored by borings. The cross-bedded and outwedged bedding of the layers concludes partly upon fluvial sediments, partly upon the frequent oscillation of the Pannonian inland sea. The capricious-bedded layers deposited near the shore of the inland see renders the exploration of the massed, petrographically uniformly developed clay strata quite difficult.

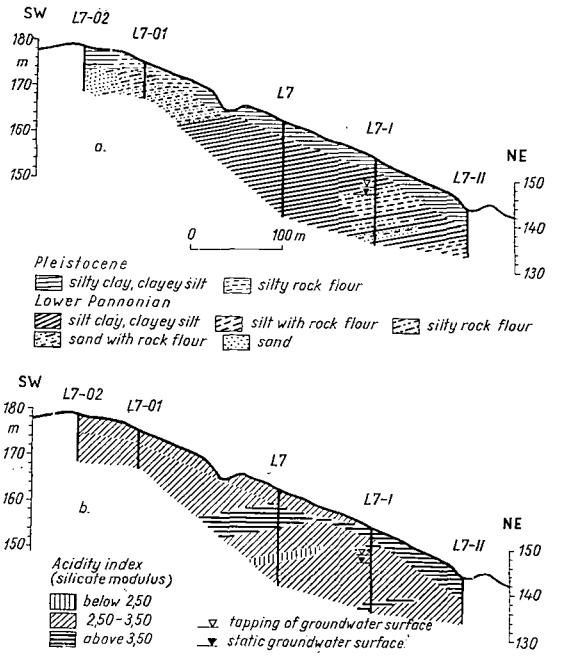

Fig. 6. SW-NE geological (a) and SM (b) profile of the Lengyelszótető exploration area

The area explored by borings is presumably cut by several smaller or greater faults whose location on the map with the help of borings, is so far still impossible.

HYDROGEOLOGICAL CONDITIONS

Surface water. In the gully, coming from the middle part of the Csoznya-tető area into approximately NE direction, a bed of a periodical waterflow runs. Besides the rain, two small wells are feeding the periodical waterflow. The well No. 1 is a wild one and the No. 2 is captured with concrete rings. We measured regularly with cubing the two wells rate of flow, in the time between 22.3—12.5. 1965. The result was: 1,8—3,0 lit/min. for the first and 2,5—2,7 lit/min. for the second well.

In the S-N and SSW-NNE running gullies, on the Western part of the Lengyelszótető exploration area, water can only be found after heavy rains or during the snow thawing.

The groundwater, in small depth below the surface, within the Csoznyatető exploration area follows the relief of the surface. The unevenness of groundwater in the Lengyelszótető area reflects upon the capricious structural and bedding conditions of the area.

The static groundwater level is situated mostly above the tapped groundwater level. This indicates that the groundwater is under pressure in consequence of the clay strata clamping.

QUALIFYING TEST OF RAW MATERIAL

A number of 82 borings 3—30 m deep, total 1293 m, in the Csoznyatető prospecting area and 27 borings, 6—25 m deep, total 407 m, in the Lengyelszótető area were accomplished with hand-drill. To decide the appropriateness of the rock material — won by test borings, for the cement-industry, and for the geological knowledge of the territory — we made manysided tests with the samples.

Chemical investigations. From the samples of the two areas 36 total and 465 partial analyses (SiO_2, Al_2O_3, Fe_2O_3 and CaO) were carried out. The average and extreme values of the total analyses are shown in *Table 1*. For the technological classification, and evaluation of reserves, silicate module values (SM) were computed from results of the partial analyses. The results of the total analysis — besides the identification, compared with results of other investigations — were used also for determination of mineral composition.

TABLE 1

*Average and extreme values of chemical analyses**

Csoznyatető	Loss on ignition	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O	MnO	SO_3	SM
	Weight %											
Average	6,55	64,04	16,58	4,94	0,56	2,96	1,10	0,92	1,93	0,14	0.52	2,99
Minimum	3,75	52,50	11,10	2,57	0,40	1,00	0,22	0,44	1,17	0,04	0,01	1,91
Maximum	10,98	74,65	19,84	7,20	0,97	7,14	2,46	1,32	2,84	0,30	1,70	4,27
Lengyelszótető												
Average	7,40	61,88	14,59	7,25	—	5,36	0,70	0,90	1,95	—	—	3,05
Minimum	3,92	51,17	9,57	4,86	—	2,93	0,16	0,66	1,17	—	—	1,90
Maximum	11,45	73,74	17,90	9,58	—	8,49	1,57	1,17	2,72	—	—	5,11

* *Remark:* Maximum and minimum values in the Table, are not everywhere datas of the same rock samples.

The distribution of the useful raw materials (silt with rock flour, clayey silt, silty clay) of the two areas based on SM values and the single intervals, respectively, are shown in *Fig. 7*, and comprised as follows:

SM value	<2,0	2,0—3,5	>3,5
Csoznyatető	4%	74%	22%
Lengyelszótető	6%	76%	18%

It is well seen on *Fig. 7* that most of the tested samples are between the SM values 2,0—3,5, further that the SM value of Pleistocene rocks belong into a well limited range. The average of the useful materials weighted SM value, is 2,84 in the Csoznyatető and 3,09 in the Lengyelszótető area.

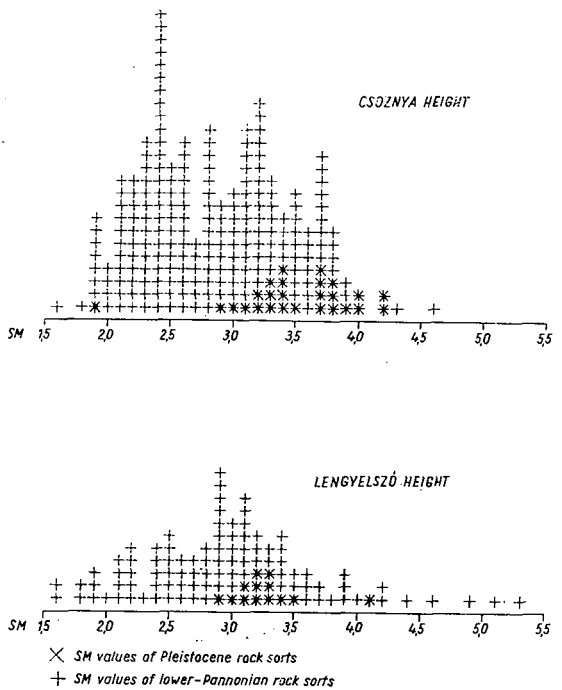

Fig. 7. SM values of the useful raw material.

The SM maps and profiles show that the chemical composition of the materials from both areas are quite heterogeneous near the surface and becomes more homogeneous toward the depth.

Thermal examinations. To ascertain the mineral composition, 70 derivatographic and dilatometric examinations of 70 samples were carried out. The derivatograms were made with the "Derivatograph" according to F. PAULIK—I. PAULIK—L. ERDEY, heating each time 1 g of air-dried material up to 1000 °C. The dilatograms were made with Leitz Bollenrath type dilatometer, with samples $4 \times 4 \times 50$ mm in size, heated to 1000 °C.

The derivatograms and dilatograms of two clay samples, characteristic for the Csoznyatető area are shown in *Fig. 8* and *9*.

The great endotherm effect under 300 °C on the DTG and DTA curves, respectively, of both figures, is characteristic of the montmorillonite. The shrinkage within the same temperature interval, seen in the dilatogram, is also typical for the montmorillonite. The endothermic peak at 550 °C on the DTG and DTA curves

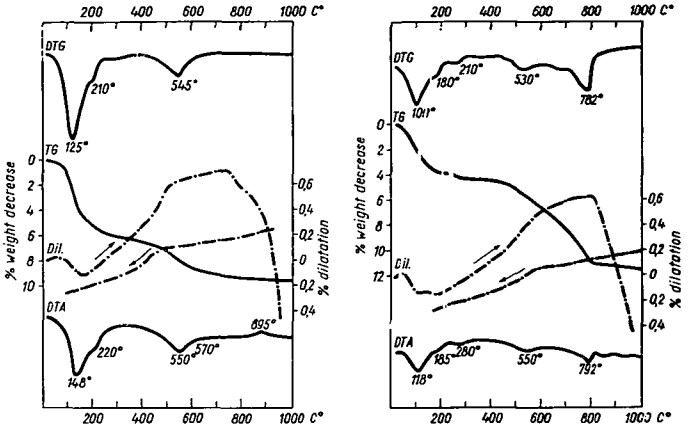

Fig. 8. Thermal curves of the Lower Pannonian silty clay, from 11,0 m depth. No. IX-3 boring of Csoznyatető.

Fig. 9. Thermal curves of the Lower Pannonian silty clay, from 17,0 m depth. No. X-6 boring of Csoznyatető.

indicates the loss of constitutional water of illite and poorly crystallized montmorillonite. In the low-temperature range sorption of Ca^{2+} and Mg^{2+} ions leads to a double-peaked endothermic reaction. One peak derives from the interlayer water of the clay mineral and the other originates in the hydration water of the sorbed bivalent cations. The dilatogram of the two materials is very similar. The initial shrinkage is followed by the dilatation of the illite and after the breakdown of the crystal lattice (at about 850—900 °C) an abrupt shrinkage can be observed. The bend on the cooling curve of the dilatogram, at about 550 °C (modification transformation) verifies the presence of quartz.

The endotherm effect at about 800 °C on the DTG and DTA curves *(Fig. 9)* originates in the decomposition of calcite. This is also connected with loss of weight (see curve TG).

A further thermogram of a sample typical for the area is shown in *Fig. 10*. This is richer in quartz and contains less clay mineral than the two former materials. Its clay minerals are also of montmorillonite and illite-type. The character of the thermogram in *Fig. 11* indicates the presence of montmorillonite, calcite and quartz and the exotherm peaks on the DTA curves point partly to organic material (330 °C) partly to pyrite (above 400 °C), respectively.

In thermograms of the samples of both areas bends relating to amorphous material of organic origin are common.

Two thermograms made from the characteristic material of the Lengyelszótetö area are shown in *Figs. 12* and *13*. On the basis of the curve in *Fig. 12* the clay mineral of the rock is illite, demonstrated by the well-marked endotherm peak at

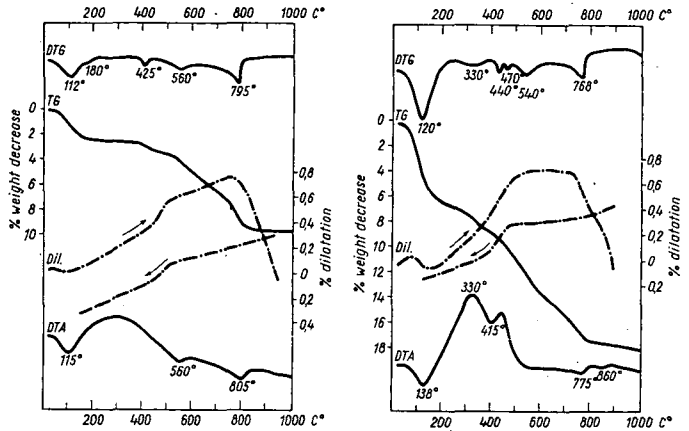

Fig. 10. Thermal curves of the Lower Pannonian silt with rock flour, from 25,0 m depth, No. X-6 boring, Csoznyatető.

Fig. 11. Thermal curves of the Lower Pannonian silty clay, from 8,0 m depth. No. VII-1 boring. Csoznyetető

570 °C. The initial range of the dilatation curve did not show montmorillonite, the cooling curve, however, indicates a greater quantity of quartz.

The sample shown in *Fig. 13* contains illite and a smaller quantity of montmorillonite. Above 300 °C on the DTG and DTA curves a pronounced endothermic peak is to be seen. This may mean the presence of some iron oxide hydrate.

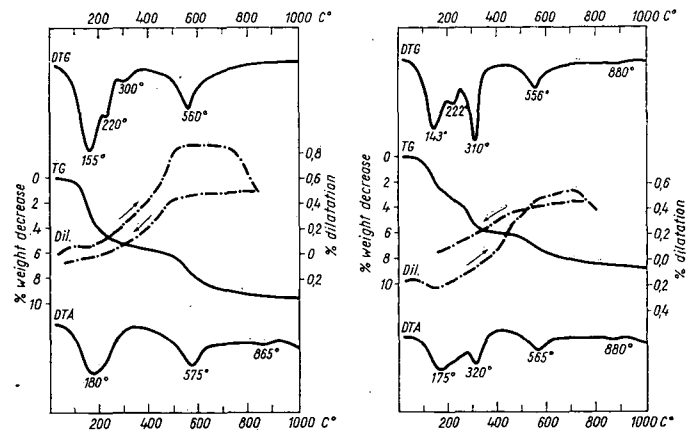

Fig. 12. Thermal curves of the Lower Pannonian clayey silt, from 15,0 m depth. No. L-9. boring. Lengyelszótető.

Fig. 13. Thermal curves of the Lower Pannonian clayey silt, from 11,0 m depth. No. L-7 boring. Lengyelszótető

The peak temperature, however, is somewhat lower than the values of goethite and lepidocrocite published in the literature. Therefore, the modification present may not be definitely identified. The iron content of such samples is considerable, at present $Fe_2O_3 = 9{,}58$ per cent.

X-ray examinations. To ascertain the quartz content, the crystal structure and mineral composition of the samples, X-ray diffractograms of 50 samples were studied. The results of these examinations are in good agreement with that of the thermal investigations. Feldspar is to be detected by X-ray examinations, whereas its thermal effect is not to be detected in the presence of illite. A small quantity of kaolinite could be determined in more than half of the examined samples. The presence of kaolinite could not be stated on the thermograms because of its poorly crystallization.

Investigation of soil mechanics. To define the state of morphology, plasticity of the materials characteristic for the area and for classification on the base of the grain size composition, the plasticity and grain size distribution were studied. The grain size distribution was determined by hydrometry in normal and peptized state.

The curves of grain size composition in *Fig. 14* show the extreme values in normal and peptized state. The difference between the two states may be explained by the strong coagulation of the clay particles in natural state. This feature is also characteristic of clay minerals with sorbed bivalent cations. The flat curves, reaching several ranges, illustrate the bad sorting of the sediments pointing to undisturbed conditions of sedimentation.

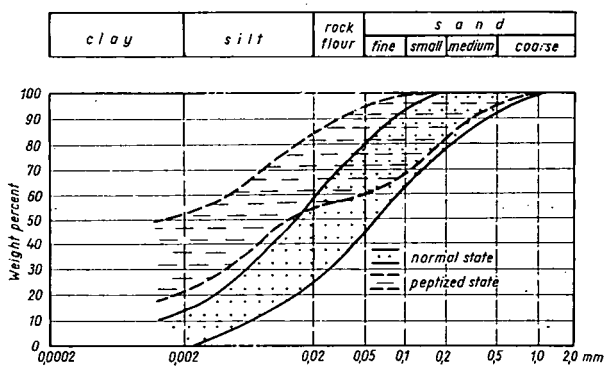

Fig. 14. Grain size curves showing only the extreme values

Some parameters well known in the soil mechanics were also determined in some of the samples collected from the Csoznyatető. These parameters are: liquid limit (F), limit of plasticity (P) and index of plasticity (P_i), value of linear shrinkage (Zs_l).

The results are summarized in *Table 2.*

TABLE 2

Symbol of the sample and the name of the rock	F %	P %	P_i %	Zs_1 %	Weight per cent of the clay fraction	
					natural state	peptized state
1	2	3	4	5	6	7
IX-00/11, 0 grey silty clay (*pa*)*	64,0	28,0	36,0	4,3	2	47
IX-00/15, 0 grey silty clay (*pa*)	60,5	27,7	32,8	8,3	3	45
IX-00/20, 0 grey silty clay (*pa*)	59,0	27,0	32,0	3,8	4	48
X-6/10,0 dark brown clayey silt with rock-flour (*pa*)	34,5	15,5	19,0	7,1	8	39
X-6/15,0 yellowish grey silt rock flour (*pa*)	35,8	20,0	15,8	8,8	0	40
X-6/20,0 yellowish-grey silt with rock flour (*pa*)	41,2	20,5	20,7	0	8,2	24
X-6/25,0 grey silt with rock flour (*pa*)	54,8	22,5	32,3	6,3	4	25
XVII-01/13,0 yellowish brown silty clay (*pa*)	46,0	18,6	27,4	5,7	15	51

* *Remark:* abbreviation (*pa*) means Lower Pannonian age.

SUMMARY

In both exploration areas, in the Lower Pannonian offshore, often lensed, cross-bedded strata near to the surface a raw-material resources of clay and clayey development, respectively, were discovered in considerable quantity.

According to chemical, instrumental as well as mechanical investigations the clayey raw-material discovered is very heterogeneous regarding its mineral composition. The three types of the clay minerals are to be found, beside the quartz, in the clay and in the strata of clayey development.

The material of the Csoznyatető area, nearer to the one time lakeshore is rather montmorillonite and that of the Lengyelszótető area, far from the shore, is to a greater extent an illite type clay mineral — after evidence of thermal and X-ray examinations.

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PALYNOLOGICAL STUDY OF LOWER PANNONIAN STRATA IN THE REGION OF GÖRÖMBÖLY

by

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Research work has so far included a pollen analysis of the near-surface, i. e. Quaternary, deposits of the Great Hungarian Plain, and also of the very thick Upper Pannonian basin filling sampled from deep borings. Of particular value seemed to be the material of the upper member of the Lower Pannonian succession sampled by GY. VITALIS at Csoznyatető, as its palynological treatment evidencing a basin margin sedimentation could enable us to make a considerable progress towards a better understanding of the Pliocene-Pleistocene stratigraphy.

It was sampled in a hill landscape of about 230 m height a. s. l., bordering the Bükk Mountains from the SE. Borehole IV-8 lies at a distance of round 300 m from borehole X-8. The upper part of the succession 30 m thick is made up of silts with limonite patches of a reddish stain intercalated locally by thin layers of mediumgrained sands; deeper on there are argillaceous silts.

As far as our knowledge goes, there are no palynological results concerning the Lower Pannonian in the Hungarian literature. Closest in geological time and space are the results obtained by E. NAGY [1958] during the examination of the Upper Pannonian brown coal deposits at the foot of the Mátra Mountains. Valuable results were furnished by É. PLANDEROVA's [1965] palynological treatment of the Tertiary at the northern fringe of the Danube Plain, Czechoslovakia. Dating by M. SZÉLES based on Ostracoda fauna classifies the whole succession of strata as Lower Pannonian. The only exception is made for the overlying sediments of Pleistocene age. Unfortunately, no description of macroflora from this well-explored area is available, though such information would largely improve palynologist's work, and in some cases even complete it.

LOWER PANNONIAN DEPOSITS

The palynological results could be represented on a diagram for the interval of 15 to 19 m of borehole IV-8 and for that of 22 to 27 m of X-8 on the basis of at least nearly 100 pollen grains. The left side of the diagram shows the distribution of all the arbor pollen grains by an areal method of representation, thus trying to portray the variation in the composition of the arbor spectrum within each particular bed and with depth. The rest of the palynological cross-section shows

detailed percentages with information on the pollen population of trees, shrubs, soft-stemmed phanerogams, cryptogams, and plant microfossils.

The diagram also includes older forms such as *Podocarpus*, *Extratriporopollenites*, Meliaceae, *Lygodium* which may have been redeposited with the sediment.

Lithologically, the samples from 15 m and 16 m of borehole IV-8 are made up of light-green silty mud; their floristic pattern is determined by the conifers whose Tertiary representatives are *Tsuga* and *Pinus haploxylon*. The samples from 18 m and 19 m depth are composed of a dark-grey argillaceous mud whose attack by hydrochloric acid released some gaseous hydrogen sulphide, an evidence for anaerobic conditions. In their pollen spectrum the ratio of the Tertiary forms was found to be prominent which is somewhat due to the presence of Tertiary conifers. A marked boom of deciduous forest is observed. It includes *Acer*, Ulmaceae, *Fagus*, *Quercus* confined to a rather dry habitat as well as *Betula*, *Alnus*, *Liquidambar*, *Carya*, and *Pterocarya* requiring more humidity in the soil. The presence of a water cover is suggested by the appearance of *Nyssa*, *Engelhardtia* associated with *Myrica* and the representatives of Ericaceae at the shrub level. Plants growing in a waterlogged environment are also the representatives of Pteridophyta such as *Osmunda*, Polypodiaceae, and Lycopodiaceae. They suggest the presence of a minor pool bordered by the deciduous forest.

In the material sampled from hole X-8 drilled a little distance to the north, the argillaceous mud became humified not higher than at 23 and 24 m depth, the rest of the samples being light-coloured. Palynologically, the greatest percentage ratio represented by the largest area on the diagram belongs to the pollen grains of *Pinus* and *Picea* suggesting a drier habitat. Humification is associated merely with an increase in the population of pollen grains (211 and 250 arbor grains, respectively), the forest pattern of the stratigraphic succession being of rather dry type. The proximity of water is indicated by the occurrence of *Alnus*, *Betula*, and *Salix*. At the shrub level the ratio of *Myrica* and Ericaceae pollen grains has decreased. *Rhus*, *Ilex* and *Corylus* may have grown on well-insolated slopes. Grassy vegetation grown at the fringes of forests: Monocotyledones, Gramineae, and *Artemisia*, a form tolerant of drought. The sedimentation of the material of X-8 appears to have taken place close to the water, but on a rather steep slope.

That the Pannonian inland sea must have been close is indicated by the abundance of the pollen grains of Chenopodiaceae, a family always concomitant of salt accumulation. It is present consistently in both boreholes, with a ratio of about 10 per cent. The same holds true for Hystrichosphaeridae, a marine microfossil represented by 2 or 3 or 4 specimens in each layer, Their joint occurrence suggests a near-coast environment [W. H. ZAGWIJN 1960, V. D. BREILE 1963]. Their presence even in samples with a very scant pollen-spore content such as those from the reaches deeper than 17 m of X-8, make believe that this was the place where the bay of the inland sea lay closest. The same holds true for the interval of 25 to 30 m of borehole IV-8.

The samples from the uppermost interval of 10 or 15 m, respectively, are extremely poor in pollen, but Ostracoda fauna is completely lacking. Still, with a view to its lithology, we can assign the succession to the Lower Pannonian stage. We may do so even because the sands overlying the upper member of the Lower Pannonian are sterile as shown by deep boring performed in the basin (personal communication by M. SZÉLES).

The sedimentation of the upper member of the Lower Pannonian seems to have taken place in the littoral zone of the inland sea. Special circumstances of

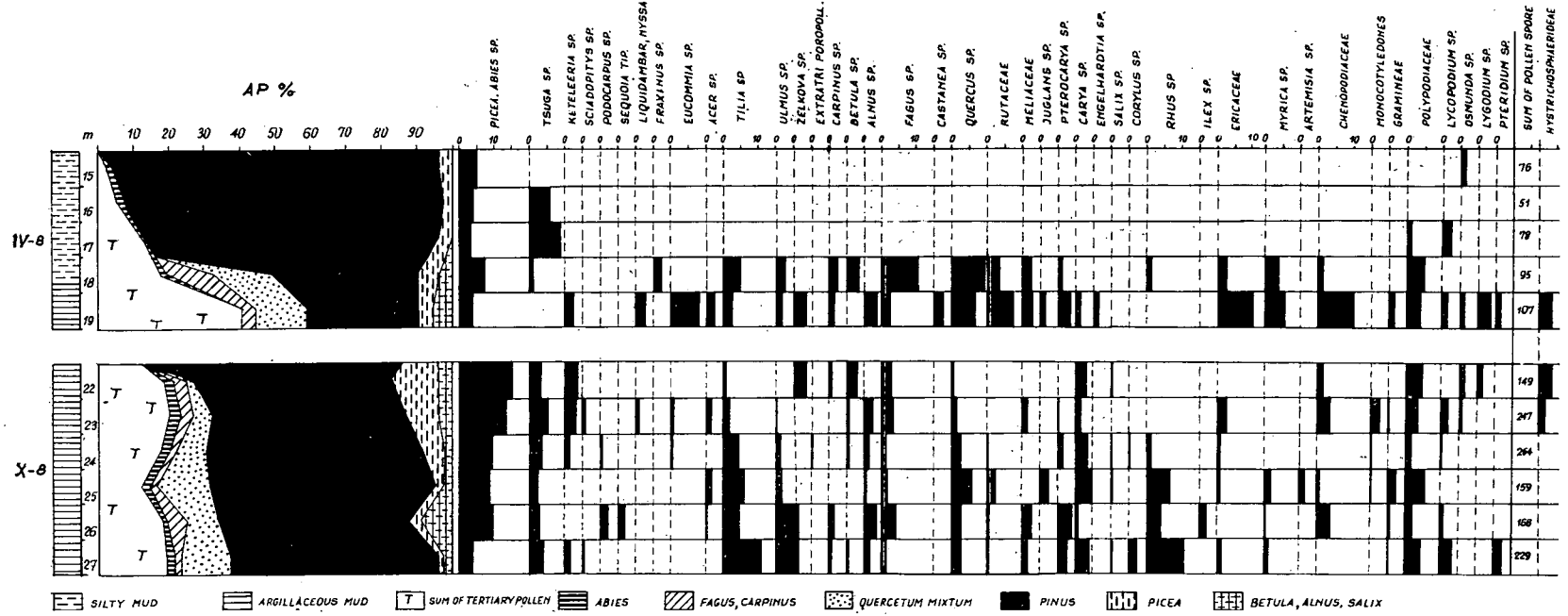

Fig. 1. Pollen diagram of boreholes Nos. IV-8, X-8 within the area of the Csoznyatető.

emplacement may have been responsible for the Lower Pannonian succession composed uniformly of argillaceous muds, a formation rather uncommonly thick for a marginal facies.

PALAEOCLIMATOLOGICAL CONCLUSIONS

The floral pattern shows a climate warmer and more humid than the present one is. The plants represented by the pollen assemblage are now-living genera, but their percentage distribution permits to conclude on a more humid climate. This more balanced, less continental climate was provided by the immediate neighbourhood of the Pannonian inland sea. The high percentage of the pollen grains of *Pinus* has resulted from local setting, for the area under consideration lay in a valley almost completely open to the north. So the winds which turned from time to time northerly could produce a cooling effect as well as they could carry the pollen grains of *Pinus*. In leeward places, however, the more eurythermous genera such as *Engelhardtia, Eucommia, Pterocarya, Nyssa,* and *Liquidambar* couldsubsist.

PLEISTOCENE

The near-surface strata were also found to contain few pollen grains. An assemblage sufficient for evaluation has been furnished by the samples taken from the brownish-grey silty mud of borehole X-8. In their arbor pollen spectrum the predominant conifers are associated with a marked ratio of mixed oak and birch. From the grassy vegetation Gramineae were encountered in every layer. At a depth of 1 m *Polygonum bistorta* and *P. convolvulus* represent antropophilic elements. This near-surface layer can be placed in the Riss—Würm interglacial, the last interglacial period of the Pleistocene Ice Age. After it, aforestation could proceed slowly so that the development of a gallery forest may be thought of. The lower boundary of the Pleistocene is obscure, being traceable rather vaguely indeed.

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